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Official Organ American Association of Economic Entomologists

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Forty-third Annual Meeting

of the

American Association of Economic Entomologists

Cleveland, Ohio

December 29, 1930 to January 2, 1931

Forty-Third Annual Meeting of the American Association of Economic Entomologists, Cleveland, Ohio

DECEMBER 29, 1930 TO JANUARY 2, 1931

The 43rd annual meeting of the American Association of Economic Entomologists will be held at Cleveland, Ohio, on the above dates. All sessions will be held in Room 24, Electricity Building, Case School of Applied Science. The Schedule has been arranged as follows:

Monday, December 29, Section of Apiculture; session 1:30 P. M.

Tuesday, December 30, Section of Quarantine and Inspection; sessions 10:00 A.M., and 1:30 P.M.

Wednesday, December 31, opening session of the general Association 10:00 A.M., afternoon session 1:30 P.M.

Thursday, January 1, sessions of the general Association in the morning and afternoon. Section of Extension Entomologists will be held in the evening.

Friday, January 2, morning session of the general Association. Final session in the afternoon.

OTHER MEETINGS

Annual meeting of the American Association for the Advancement of Science, its sections and affiliated societies, will be held December 30, 1930 to January 2, 1931.

The Entomological Society of America will meet on Tuesday and Wednesday, December 30 and 31. The public address before that society will be given on Tuesday evening.

HOTEL HEADQUARTERS

Hotel Headquarters for this Association will be at the Hollanden Hotel, Superior Avenue and East 6th Street. The following rates have been secured:

Single rooms	$3.00 up
Double rooms	6.00 up

(All rooms with baths)

RAILROAD RATES

Reduced rates have been secured which apply to practically all of the United States and Canada on the certificate plan. The traveler when purchasing his ticket should pay the full one-way fare and request a

certificate for the meeting of the American Association for the Advancement of Science. This certificate must be deposited for validation at the registration office which will be located in the gymnasium of the Western Reserve University. The registration fee for each ticket is one dollar for members of the American Association for the Advancement of Science and two dollars for all others. This certificate will be accepted for return passage at one-half the one-way rate.

Entomologists Dinner

The Entomologists Dinner will be held on Wednesday Evening, December 31. The exact time and place will be announced at the meeting.

Membership

Applications for membership can be secured from the Secretary or from the committee on membership. They should be filled out, properly endorsed and filed with the Membership Committee on or before December 31, and must be accompanied by a fee of $4.00.

Program

Monday Afternoon Session, December 29, 1:30 Room 24, Electricity Building, Case School of Applied Science

Section of Apiculture

R. L. Parker, *Chairman* F. B. Paddock, *Secretary*

Appointment of Committees.

Address by the Chairman, R. L. Parker, Manhattan, Kansas.

Symposium on Honey. This symposium will be led by—

E. F. Phillips, Ithaca, N. Y.
H. F. Wilson, Madison, Wisc.
F. B. Paddock, Ames, Iowa.

General discussion.

1. A Colony of Bees Exposed to High External Temperatures—W. E. Dunham, Columbus, Ohio.

2. Metabolism of the Adult Honey Bee—M. D. Farrar, Urbana, Ill.

Discussion of the most pressing apicultural problems.
Reports of Committees.
Selection of Officers.
Adjournment.

Tuesday, December 30, Field trip to A. I. Root Co. plant, Medina, Ohio: leaving Cleveland at 10 A. M.

Program

Tuesday Morning Session, December 30, 10:00 Room 24, Electricity Building, Case School of Applied Science.

SECTION OF PLANT QUARINTINE AND INSPECTION

E. N. CORY, *Chairman* S. B. FRACKER, *Secretary*

Appointment of Committees on Resolutions and on Nominations.

Address by the Chairman, E. N. Cory, College Park, Maryland.

1. Review of the Work of the Plant Quarantine and Control Administration for the past year. L. A. Strong, Washington, D. C.

2. Progress in Mediterranean Fruit Fly Eradication. W. C. O'Kane, Durham, N. H.

3. The Present Status of the European Corn Borer in the United States. L. H. Worthley, Boston, Mass., and E. G. Brewer, Toledo, Ohio.

4. The European Corn Borer Situation in Ontario in 1930. L. S. McLaine, Entomological Branch, Department of Agriculture, Ottawa, Canada, and Lawson Caesar, Ontario Agricultural College, Guelph, Ont.

5. The Eradication of Isolated Gipsy Moth Outbreaks. A. F. Burgess, Melrose Highlands, Mass.

6. Plant Quarantine Policies and Procedure in Cuba. Ernesto Sanchez Estrada, Department of Agriculture, Commerce and Labor. Havana, Cuba.

Program

Tuesday Afternoon Session, December 30, 1:30; Room 24, Electricity Building, Case School of Applied Science

SECTION OF PLANT QUARANTINE AND INSPECTION

7. Recent Developments in the Problem of the Removal of Arsenical Residues. D. F. Fisher, Washington, D. C.

8. Comments on the Certification of Apples for Export to Great Britain. A. W. Gilbert, Boston, Mass.

9. Humid Heat as a Treatment to Eliminate Infestation—A Preliminary Report. Lon A. Hawkins, Washington, D.C.

10. Legal and Practical Aspects of the Relationships between the Federal and State Quarantine Officers and between National and Regional Plant Boards. Thos. J. Headlee, New Brunswick, N. J.

11. Bacterial Canker of Tomato and its Distribution with the use of seed from Diseased Fruits. L. M. Fenner, Columbus, Ohio.

12. Export Certification—Policies and Results. E. R. Sasscer, Washington, D. C.

13. Recent Investigational Work on Fumigation in Florida. A. F. Camp, Gainesville, Fla.

14. The Present Status of Sweet Potato Weevil Control and Certification in Texas. J. S. Woodard, Austin, Texas.

15. Report of the National Plant Board—including special report on the principles of Plant Quarantines. R. W. Leiby, Raleigh, N. C.

16. Reports of the Regional Boards:

The Eastern Plant Board. T. J. Headlee, Chairman, New Brunswick, N. J.

The Southern Plant Board. B. P. Livingston, Chairman, Montgomery, Ala.

The Central Plant Board. E. L. Chambers, Chairman, Madison, Wisc.

The Western Plant Quarrantine Board. W. C. Jacobsen, Secretary, Sacramento, Calif.

Report of Resolutions Committee.

Report of Nominating Committee.

Selection of Officers.

Adjournment.

Program

Wednesday Morning Session, December 31, 10; Room 24, Electricity Building, Case School of Applied Science

American Association of Economic Entomologists

Report of the Secretary.

Report of the Executive Committee, by President Franklin Sherman.

Report of the Representative to the National Research Council, by W. A. Riley, St. Paul, Minn.

Report of the Governors of the Crop Protection Institute, by W. C. O'Kane, Durham, N. H.

Report of Scientific Trustee, Tropical Plant Research Foundation, by Herbert Osborn, Columbus, Ohio.

Report of the Representative on the Council of the Union of Biological Societies, by A. L. Quaintance, Washington, D. C.

Report of the Committee on Nomenclature, by J. A. Hyslop, Washington, D.C.

Report of Committee on Endowment, by A. F. Burgess, Melrose Highlands, Mass.

Report of Editorial Board on Index to Economic Entomology, by E. P. Felt, Stamford, Conn.

Report of Board of Trustees for Permanent Fund, by A. F. Burgess, Melrose Highlands, Mass.

Report of the Committee on National Museums, by J. J. Davis, Lafayette, Ind.

Report of Co-ordinating Committee on Program, by Alvah Peterson, Columbus, Ohio.

Report of Committee to Formulate Plans for Investigation of the Codling Moth from Biologic and Control Standpoints, by A. L. Quaintance, Washington, D. C.

Report of Committee on Research Work on the Control of the European Corn Borer, by G. A. Dean, Manhattan, Kansas.

Report of Committee on Recommendations to Secretary of Agriculture with reference to Needs for Foreign Stations to Study Insect Pests, Plant and Animal Diseases Introduced or likely to be Introduced, by Herbert Osborn, Columbus, Ohio.

Report of Committee on Training of Entomologists, by C. J. Drake, Ames, Iowa.

Report of the sub-committee on Entomological Exhibits for the Chicago Century of Progress Exposition, by W. P. Flint, Urbana, Ill.

Appointment of Committees.

Miscellaneous Business.

New Business.

Annual Address of the President, Franklin Sherman, Clemson College, S. C.

1. Census Taking in Entomology.

Discussion of Presidential Address.

READING OF PAPERS

Insects Affecting Greenhouse Plants

2. Red Spider Control in Greenhouses. (5 min.) C. C. Compton, Urbana, Ill.

3. The Effect of Temperature on Feeding and Development of the Greenhouse Leaftyer, *Phlyctaenia ferrugalis* Hb. (5 min.) (Lantern) G. A. Filinger, Wooster, Ohio.

A discussion of the amount of food eaten by greenhouse leaftyer larvae and the amount of time required to mature the larvae at different temperatures.

INSECTS AFFECTING ANIMALS

4. Nicotine in the Control of Ecto-parasites of Poultry. (5 min.) F. C. Bishopp and R. D. Wagner, Washington, D. C.

The results are presented of experiments with nicotine sulphate and free nicotine in the control of poultry parasites, particularly lice and mites.

Program

Wednesday Afternoon Session, December 31, 1:30; Room 24, Electricity Building, Case School of Applied Science.

READING OF PAPERS

INSECTS AFFECTING DECIDUOUS FRUITS.

5. Notes on the European Hornet. (3 min.) (Lantern) E. N. Cory, College Park, Md.

Occurrence, injuries to shrubs and fruit, nesting habits, population and proportion of castes.

6. The Cherry Case Bearer, *Coleophora pruniella* in Michigan (5 min.) Ray Huston, East Lansing, Mich.

A survey of the present distribution and abundance of this insect with data upon damage caused by it.

7. Control of the Cherry Case Bearer, *Coleophora pruniella* Clem., by Oil Sprays. (5 min.) (Lantern) A. A. Granovsky, St. Paul, Minn.

The lubricating oil cold mix emulsion gave the best results.

8. A Preliminary Report on Large Scale Bait Trapping of the Oriental Fruit Moth in Indiana and Georgia. (5 min.) W. P. Yetter, Jr., Vincennes, Ind., and L. F. Steiner, Cornelia, Ga.

A brief account of the first year's work of the large scale bait trapping experiments being conducted at Vincennes, Indiana and Cornelia, Georgia.

9. Results of Spraying and Dusting Experiments with the Control of the Curculio Attacking Peaches during the 1930 Season. (5 min.) O. I. Snapp, Fort Valley, Ga.

Comparative effectiveness of dusts carrying 5 and 10 per cent lead arsenate and the standard lead arsenate spray, and the value of adding fish oil to the sprays and of an application of lead arsenate when the buds are pink.

10. The Broods of the Plum Curculio, *Conotrachelus nenuphar* Herbst., in Delaware. A Preliminary Report. (5 min.) (Lantern) L. A. Stearns, Newark, Del.

Reports data obtained in a preliminary study of one-brooded and two-brooded curculio in Delaware.

11. Relation of Environment on Pear Psylla Infestation. (5 min.) (Lantern) F. Z. Hartzell and F. L. Gambrell, Geneva, N. Y.

Susceptibility of orchards to intensity of pear psylla attack has been found to be associated with variation in the environment under New York conditions. Suggestions are offered for modifying surroundings to lessen the injury by this insect.

12. Notes on Pear Psylla Control. (5 min.) (Lantern) F. Z. Hartzell, Geneva, N. Y.

Use of dormant oil sprays and summer oil treatments are discussed, with notes on material, time of application and effect on insects and trees. Some attention will be given to modifications in treatments with other insecticides.

13. Controlling Fruit Tree Leaf Roller with Oil Sprays. (5 min.) G. S. Tolles, East Lansing, Mich.

Results of laboratory and field tests of oil sprays in controlling the fruit tree leaf roller.

14. The Role of Yeast in Life History Studies of the Apple Maggot, *Rhagoletis pomonella* Walsh. (5 min.) C. L. Fluke Jr., and T. C. Allen, Madison, Wisc.

Rearing of the apple maggot was readily secured by feeding the adult flies a simple solution consisting of one to three per cent yeast in five per cent honey water. The flies lived for many days, readily mating and ovipositing in small cages in the field or laboratory.

15. Apple Maggot Investigations in 1930. (5 min.) (Lantern) P. J. Chapman, A. B. Burrell and F. G. Mundinger, Geneva, N. Y.

A general report of studies on the apple maggot in New York State in 1930, including notes on spray residue experiments.

16. Trends in Codling Moth Control in the Pacific Northwest. (5 min.) (Lantern) R. L. Webster and Anthony Spuler, Pullman, Washington.

Changes in spraying practice, particularly in orchard-growing sections of Washington, with special reference to improved spray equipment, summer oils, and the use of codling moth traps to determine spray dates.

17. Some Laboratory Reactions of Young Codling Moth Larvae. (5 min.) (Lantern) C. R. Cutright, Wooster, Ohio.

Data regarding the activities of young larvae at different temperatures on sprayed and unsprayed fruit.

18. Organic Solvents for Aiding the Removal of Spray Residue from Waxy or Oil Sprayed Fruit. (5 min.) (Lantern) R. H. Robinson, Corvallis, Oregon.

When certain organic solvents, such as alcohol, benzine, kerosene, gasoline, etc., or emulsions of some of these are added to the hydrochloric acid washing solution, waxy or oil sprayed fruit is more effectively cleaned.

19. A Study of Arsenical Residues on Apples in Pennsylvania with Respect to Efficient Spraying practices, II. (5 min.) H. E. Hodgkiss and D. E. Haley, State College, Pa.

A review of spray residue conditions during a season of minimum rainfall.

Insecticides

20. Preliminary Notes on the Chemistry of Codling Moth Baits. (5 min.) (Lantern) J. R. Eyer, State College, N. M.

21. The Radioactive Indicator Method of Estimating the Solubility of Acid Lead Arsenate within the Alimentary Tract of the Silkworm. (5 min.) (Lantern) F. L. Campbell and Chas. Lukens, Takoma Park, Md.

22. Copper Carbonate, Arsenate of Lead, and Other Compounds Used Against the Mediterranean Fruit Fly, *Ceratitis capitata* Wied., on Citrus in Florida. (5 min.) (Lantern) R. L. Miller, Orlando, Fla.

23. Problems in the Manufacture of Liquid Household Insecticides of the Petroleum Extract of Pyrethrum Type. (5 min.) Alfred Weed, New York, N. Y.

The manufacturer of these products is confronted with a number of perplexing questions which include: the concentration of the toxic constituents to be used, the use of Pyrethrum powder or concentrated extracts in preparing his product, the selection of satisfactory petroleum fractions and perfumes.

24. Studies on the Use of Extracts of Pyrethrum Flowers as Insecticides. (5 min.) H. G. Walker, Columbus, Ohio.

25. An Insecticidal Method for the Estimation of Kerosene Extracts of Pyrethrum. (5 min.) (Lantern) H. H. Richardson, Ames, Iowa.

Description of and results of the method are included. Statistical study of the results indicates that the speed of action is a diagnostic character of various strengths of pyrethrum extract.

26. A Preliminary Report on the Insecticidal Properties of Devil's Shoe String, *Cracea virginiana* L. (5 min.) V. A. Little, College Station, Texas.

This is a study of the comparative toxicity of this plant under laboratory and field conditions.

27. Studies on Hydrated Ferric Oxide as Corrective, Spreader and Sticker. (5 min.) (Lantern) J. M. Ginsburg, New Brunswick, N. J.

Experiments with Ferroskim, a mixture of ferric oxide and powdered skim milk, have shown that this product increases the adhesive and sticking properties of lead arsenate and nicotine tannate. It also acts as a corrective for arsenical injury on apple foliage.

28. The Function of Emulsifying and Spreading Agents in Oil Sprays. (5 min.) R. H. Smith, Riverside, California.

Results of research on the part Played by Emulsifers and Spreaders in the use of Oil Sprays.

29. Tests with Nicotine Activators. (5 min.) E. P. Felt and S. W. Bromley, Stamford, Conn.

Comparative results obtained in field tests with several types of nicotine activators.

30. Preliminary Report on Rotenone as an Insecticide. (5 min.) (Lantern) M. M. Darley, Columbus, Ohio.

Rotenone-Penetrol combinations compared with other standardized contact insecticides. Rotenone as a stomach poison.

Program

Thursday Morning Session, January 1, 10:00; Room 24, Electricity Building, Case School of Applied Science.

READING OF PAPERS

Insects Affecting Forest and Shade Trees.

31. An Experiment with Summer Oil for the Control of the European Elm Scale, *Gossyparia ulmi* L. (5 min.) C. R. Cleveland, Chicago, Ill.

Application of a summer or white oil emulsion in early July to nursery grown elms heavily infested by this insect produced highly effective control at 2% concentration of the emulsion. Data relative to influence of time and methods of application, insecticidal action of the oil, and tolerance of the trees to oil injury, are presented.

32. Preliminary Notes on the Biology and Control of the Pine Leaf Scale. (5 min.) A. G. Ruggles, St. Paul, Minn.

33. The Spruce Gall Aphis as a Nursery Problem. (5 min.) (Lantern) F. L. Gambrell, Geneva, N. Y.

A brief resume of the data obtained during the past 3 years relative to the life history and control of the spruce gall aphis are summarized together with information secured from the use of various insecticides as to their safety and relative efficiency.

34. Carpenter Worm Injury to Ash Trees in North Dakota. (5 min.) J. A. Munro, Fargo, N. D.

Observations made indicate that the Carpenter worm has confined its attack exclusively to ash trees in the Fargo vicinity. This paper includes notes on the life habits together with suggestions for control of the pest. The Arkansas king bird proved to be the most efficient natural control agent.

Insects Affecting Cereal and Forage Crops.

35. A Comparison of the Feeding Habits of Some Species of Empoasca. (5 min.) (Lantern) F. F. Smith and F. W. Poos, Rosslyn, Va.

A histological study of the areas on leaves, petioles and stems of plants exposed to *E. fabae* (Harris), and to several other species of Empoasca, has been made to determine the particular tissues fed upon by each species.

36. A Comparison of Oviposition and Nymphal Development of *Empoasca fabae* (Harris) on different Host Plants. (5 min.) (Lantern) F. W. Poos and F. F. Smith, Rossyln, Va.

Report on experiments to determine choice of oviposition and percentage of nymphs developing to adults on different species of plants. Some forage crop legumes were tested with special reference to their types of pubescence.

37. Seasonal History Studies on the European Corn Borer in Michigan. (5 min.) (Lantern) G. T. Bottger and V. F. Kent, U. S. Bureau of Entomology.

Results of observations conducted under both field and insectary conditions over a period of five years.

38. Some observations on the Planting Date of Corn in Relation to Corn Borer Population. (5 min.) G. A. Ficht, Lafayette, Ind.

Three year's observations on the effect of planting date of corn on borer population are given along with a discussion of some of the factors governing the differences in populations of the plantings.

39. Correlation between Corn Borer Survival and Maturity of Corn. (5 min.) (Lantern) E. G. Kelsheimer and J. B. Polivka, Wooster, Ohio.

Data presented show a significant correlation between borer survival and host development.

40. Migration and Dissemination of European Corn Borer Larvae. (5 min.) (Lantern) C. R. Neiswander and J. R. Savage, Wooster, Ohio.

This paper gives the results of experiments on the amount of distance of larval dissemination and on the period of migration.

41. Some Causes contributing to European Corn Borer Abundance. (5 min.) (Lantern) L. L. Huber and C. R. Neiswander, Wooster, Ohio.

This paper consists of a brief analysis of the major causes contributing to the reduction in European corn borer population in Ohio in 1930.

42. The Effects of Physiological Change in the Corn Plant on European Corn Borer Establishment. (5 min.) (Lantern) J. B. Polivka, Wooster, Ohio.

Data presented indicate that the reduction in corn borer infestation as a result of the use of insecticides is due in part to the disturbance of the physiology of the plant.

43. The Lethal Power of Certain Insecticides Tested in Michigan Against the European Corn Borer. (5 min.) (Lantern) F. L. Simanton, F. F. Dicke and G. T. Bottger, Monroe, Mich.

44. Notes on Parasitism and Infestation by *Pyrausta nubilalis* in Europe in 1929. (5 min.) H. L. Parker, A. M. Vance and H. D. Smith, Hyeres, France.

Condensed data on parasitism by zones and infestation in 1929 in Italy and France.

45. *Pyrausta nubilalis* Hubn. Handling of Single Generation Larvae to Supply Parasite Data. (5 min.) W. A. Baker and Ralph Mathes, Monroe, Mich.

A discussion of the effect of time of collection and relation of diapause and moisture requirements to laboratory handling of single generation European Corn Borer Larvae.

46. The Soy Bean Caterpillar in Louisiana. (5 min.) (Lantern) W. E. Hinds and B. A. Osterberger, Baton Rouge, La.

Outline of its occurrence, life history, control and natural enemies as found in 1930.

47. The Wheat Straw Worm, *Harmolita grandis* Riley, in Utah. (5 min.) G. F. Knowlton, Logan, Utah.

The wheat straw worm is generally distributed throughout northern Utah, and damage to irrigated and dry-farm wheat was apparent in many areas.

48. Anatomy of the Hessian Fly Larva. (5 min.) (Lantern) Leonard Haseman, Columbia, Mo.

49. Reaction of Sorghum Varieties and Hybrids to Chinch Bugs. (5 min.) (Lantern) R. H. Painter, Manhattan, Kansas.

Under chinch bug attack, sorghums vary greatly in percentage of plants killed and amount of injury. The resistance of certain varieties is inherited independent of desirable agronomic characters.

50. Grub Infestation as a possible Indication of Crop Selection by May bettles for Egg Laying. (3 min.) K. Koch and C. L. Fluke, Jr. Madison, Wisconsin.

Population studies of the white grub show that there are fewer grubs in certain legumes, indicating that adult beetles are plant selective in egg laying habits.

Program

Thursday Afternoon Session, January 1, 1:30; Room 24 Electricity Building, Case School of Applied Science.

Insects Affecting Household and Stored Grain

51. Paradichlorobenzene as a Fumigant for Clothes Moths. (5 min.) G. W. Herrick and G. H. Griswold, Ithaca, N. Y.

52. A Preliminary Report on the Effectiveness of Sodium Fluosilicate as Compared with Borax in Controlling the House Fly. (5 min.) (Lantern) S. Marcovitch and M. V. Anthony.

53. Protecting Stored Grain from Insects by the Use of Oils. (5 min.) (Lantern) W. P. Flint, Urbana, Ill.

Dipping or spraying corn with certain miscible oils and oil emulsions has protected such corn from insect injury when kept in storage where stored grain insects were excessively abundant. Tests are under way with other grains. Experiments reported extending over a three-year period.

Miscellaneous Papers

54. Various Types of Insect Olfactometers used in America and South Africa. (5 min.) (Lantern) N. E. McIndoo, Takoma Park, Washington, D. C.

Three types of olfactometers will be briefly described and illustrated with lantern slides

55. A New Automatic Insect Trap for the Study of Insect Dispersion and Flight Association. (5 min.) (Lantern) R. A. Fulton and J. C. Chamberlin, Twin Falls, Utah.

An Insect trap which automatically receives and retains the insects borne by a representative moving current of air is described, and its application to studies of insect dispersal and flight associations, with especial reference to *Eutettix tenellus* Baker, is discussed.

56. The Differential Between the Effect of Radio Waves on Insects and on Plants. (5 min.) (Lantern) T. J. Headlee, New Brunswick, N. J.

There seems to exist a satisfactory differential between the effect of radio waves on insects and the effect of these same waves on certain plant hosts.

57. Developing Resistance or Tolerance to Insect Attack. (5 min.) E. P. Felt and S. W. Bromley, Stamford, Conn.

A discussion of the effect of plant vigor upon resistance or tolerance to insect attack.

58. A Comparison Between the Temperature and Humidity within Common Types of Insect Rearing cages and the Outside. (5 min.) (Lantern) R. C. Smith, Manhattan, Kansas.

A series of studies to see whether a hygrothermograph in an insectary or in the field beside cages indicated the temperature-humidity conditions in the cages.

59. An Incubator Room. (5 min.) (Lantern) W. A. Baker and K. D. Arbuthnot, Monroe, Michigan.

Details of construction and installation of equipment in an insect incubation chamber utilized in rearing European corn borer parasites.

60. The Present Status of the Introduced Parasites of *Popillia japonica* New. (5 min.) J. L. King, Moorestown, N. J.

61. The Application of Artificially Delaying *Microgaster tibialis* Nees, Development to Emergence and Liberation. (5 min.) W. A. Baker and K. D. Arbuthnot, Monroe, Michigan.

Discussion of results obtained by use of cold storage and its application to handling of adults for liberation, also results of some other methods which have been tried.

62. Artificial Rearing and Colonization of *Trichogramma minutum*. (5 min.) D. F. Farlinger and C. H. Alden, Cornelia, Ga.

Two years results on rearing and colonization of *T. minutum* on peach, apple and pecan insects of Georgia.

63. New Methods for Liberating *Trichogramma minutum* in Field and Orchard. (5 min.) A. W. Morrill, Los Angeles, Calif.

Methods devised by the author to facilitate the successful liberation of the parasite and to overcome certain difficulties encountered in large scale operations are described.

64. Some Notes on the Refrigeration of Insect Eggs Parasitized by *Trichogramma minutum*. (5 min.) A. Peterson, Columbus, Ohio.

Some information on the species of insect eggs and the temperature and moisture required to carry *Trichogramma minutum* in a living state for several months.

65. A Simple Filing System for a State Insect Pest Survey. (5 min.) (Lantern) J. A. Hyslop, Washington, D. C.

66. The Potato Leaf Hopper and its Close Relatives of Empoasca occurring on Truck Crops in the United States. (5 min.) (Lantern) D. M. DeLong, Columbus, Ohio.

A brief discussion of the species concerned and the areas of occurrence in the United States.

67. A Comparison of Mercury Compounds in Root Maggot Control. (5 min.) H. Glasgow, Geneva, N. Y.

68. A Preliminary Report on the Lima Bean Pod Borer and other Legume pod Borers in Porto Rico. (5 min.) M. D. Leonard and A. S. Mills, Rio Piedras, Porto Rico.

Preliminary observations on the distribution, life history economic importance and food plants of *Maruca testulalis* Geyer. Notes are also given on several other lepidopterous pod borers of legumes and on their parasites.

69. Studies of *Eutettix tenellus* Baker in 1930 in Southern Idaho. (5 min.) (Lantern) P. N. Annand, J. C. Chamberlin, C. F. Henderson and H. A. Waters, Twin Falls, Idaho.

A review of the 1930 dispersal and prediction of *E. tenellus* attack is given together with data relative to direction, source, and length of time involved in the flight.

70. Effect of Protective Covering Upon the Overwintering of Eggs of the Pea Aphid *Illinoia pisi* Kalt. (5 min.) T. E. Bronson, Madison, Wisconsin.

Eggs were placed in small mesh cages and given various degrees of protection in the field. Temperature conditions were recorded.

71. *Pangaeus uhleri* Sign., A Pest of Spinach. (5 min.) G. E. Gould, Norfolk, Va.

A Burrower-bug, *Pangaeus uhleri* Sign., was observed attacking spinach just as the seedlings were pushing through the ground. Although the infestation was confined to a few fields, the seriousness of the damage this year shows that the insect is sometimes of economic importance. Several unusual habits of the insect are recorded.

72. Observations on the Wintering habits of the Striped Cucumber Beetle. (5 min.) Leonard Haseman, Columbia, Mo.

Program

Thursday Evening Session, January 1, 8:00; Room 24, Electricity Building, Case School of Applied Science.

Section of Extension

C. R. Crosby, *Chairman* T. H. Parks, *Secretary*

1. Extension Entomology. C. R. Crosby, Ithaca, N. Y.
2. Ox Warble Control in Northern Illinois. C. C. Compton, Urbana, Ill.

3. Directing Red Spider Control Through the Use of Special Tags on Nursery Stock. E. L. Chambers, Madison, Wis.

4. Outbreak of Corn Earworm in Missouri. Leonard Haseman, Columbia, Mo.

5. Developments of Argentine Ant Control and Eradication in Mississippi. R. W. Harned, Agricultural College, Miss.

6. Climatic Conditions and Their Effect upon the Sugar Cane Borer Population in Louisiana in 1930. W. E. Hinds and B. A. Osterberger, Baton Rouge, La.

SYMPOSIUM

Effect of the 1930 Drought Upon Insect Population.

Cereal Crop Insects, W. H. Larrimer, Washington, D. C., W. P. Flint, Urbana, Ill.

Forage Crop Insects, Herbert Osborn, Columbus, Ohio, J. J. Davis, Lafayette, Ind.

Forest and Shade Tree Insects, J. S. Houser, Wooster, Ohio.

Fruit Insects, W. J. Schoene, Blacksburg, Va.

Truck Crop Insects, P. D. Sanders, College Park, Md., Neale Howard, Columbus, Ohio.

General Discussion.

Selection of Officers.

Program

Friday Morning Session, January 2, 10:00; Room 24, Electricity Building, Case School of Applied Science.

FINAL BUSINESS

Report of Committee on Resolutions.

Report of Committee on Membership.

Reports of other committees.

Nomination of Journal officers by Advisory committee.

Report of Committee on Nominations.

Election of Officers.

Miscellaneous business.

Fixing the time and place of next meeting.

Final adjournment.

FRANKLIN SHERMAN, *President*,
Clemson College, S. C.

A. F. BURGESS, *Secretary*,
Melrose Highlands, Mass.

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LABORATORY TESTS OF MISCELLANEOUS CHEMICALS AGAINST THE CODLING MOTH

By L. C. McALLISTER, JR., *Assistant Entomologist* and E. R. VAN LEEUWEN, *Associate Entomologist, Deciduous Fruit Insect Investigations, Bureau of Entomology, United States Department of Agriculture*

ABSTRACT

During the years 1920 to 1928, inclusive, studies were made to determine the toxicity of many materials to newly hatched codling moth (*Carpocapsa pomonella* L.) larvae. Numerous tests were made in a rather hasty survey for a possible arsenical substitute with the idea of helping to develop a poison which could be used in a practical way and which would not be objectionable on fruit at harvest. Although no chemical was found which could substitute for lead arsenate in a practical way, several materials were strongly toxic to codling moth larvae.

The recent objection to fruits and vegetables sprayed with arsenicals reaching the market with excessive spray residue has suggested the development of a material which can be substituted for the arsenicals in the control of certain chewing insects. With the idea in mind of finding a material which would be toxic to insects and non-toxic to man as well as meet certain other requirements of a stomach poison, studies were begun in the early summer of 1926 to determine the toxicity of many materials of promise and others which had never been tested before as insecticides. The primary reason for conducting these tests was to obtain indications of effectiveness of the materials tested for preventing entrance of codling moth larvae into treated apples under the conditions of the experiments. Little attention was given to other features of the materials tested. The results of these tests, against newly hatched larvae of the codling moth (*Carpocapsa pomonella* L.), conducted during the years of 1926, 1927, and 1928, are reported in this paper.

METHODS AND TECHNIQUE. The method employed in these experiments is similar, with a few minor changes, to that used by R. H. Smith (*5*)[1] and by E. J. Newcomer (*4*). This method when employed

[1]Reference is made by italic numbers in parentheses to "Literature Cited," P. 922.

against the codling moth avoids many of the uncontrollable factors met with in orchard work. Accordingly, a large number of laboratory tests were made consisting essentially of spraying a given number of apples, placing a given number of newly-hatched codling moth larvae on them, and later recording the number of worm holes and stings. This method can be used to show the relative value of various materials, of various dilutions of each material, and of combinations with other spray materials. The ease with which this method can be employed enables the investigator to carry out a large number of tests in a single season and to make direct comparisons of a large number of treatments. Obviously, this method gives only an index of the value of the material used at the time it is applied. It is of no value in determining the durability or adhesiveness of the material, or of the relative effect of various methods of application (such as by means of a spray gun or rod), or of the various numbers of applications. Nearly 2,000 tests of this nature, in which 46,960 newly hatched larvae were used, have been made at the fruit-insect laboratory of the United States Bureau of Entomology at Moorestown, New Jersey.

Securing Newly Hatched Larvae. Burlap bands were placed around the trunks of apple trees at Glassboro, New Jersey, which were heavily infested with the codling moth. From these bands thousands of over-wintering larvae were collected. These larvae were placed in battery jars containing corrugated paper strips cut to a convenient size, and in these the larvae developed. The development of many of the larvae was retarded in the late spring by placing them in a space formed between two cold storage rooms where the temperature was continuously about 45°F. The purpose of retarding the development was to prolong the period of emergence of adults. This prevented all of the moths from coming out at one time and gave a continuous supply of adults.

The newly emerged moths were placed in cages to lay eggs. The cages were 6 inches by 6 inches by 12 inches in size and so constructed that the 16-mesh wire screen was attached inside the supports. A covering of moist sand about one-half inch thick had been previously placed in the bottom of each cage and covered with 16-mesh wire screen to prevent the moths depositing eggs in the sand. Fresh pear foliage was inserted for the deposition of eggs. Approximately 100 moths equally divided as to sex were placed in each cage. The pear foliage was replaced each day and the eggs on the leaves and stems counted and placed in separate jars. As soon as the black spot appeared the eggs were transferred to a clean jar. The newly hatched larvae were easily removed from the side of the glass jar, where most of them went.

PREPARATION OF APPLES. Unsprayed apples of Grimes Golden variety and free from injury of any kind were used for all tests. The apples ranged in size from 1 inch to 2 inches in diameter. The calyx cups were filled with paraffin and each apple was suspended by a piece of black cotton thread tied to its stem. Five apples were used in each test and for ease of handling the apples were suspended by different lengths of thread tied to a single strip of wood, the distance between apples being about three inches.

SPRAYING AND DUSTING. A hand sprayer of 1-quart size was used to apply the materials used in sprays. Each apple was slowly rotated to insure a thorough covering of material. The coverage was not always uniform but it was of such a nature that the insect eating the apple would first have to eat through some of the spray deposit. The spray was applied until the drops ran together, but application was stopped before any of the solution ran off the apple. All the materials mentioned in Table 1 were applied as sprays.

Most of the materials were applied in the form of a dust. If the material to be tested was not already fine enough, it was ground to a fine powder. The liquid materials were incorporated with an inert carrier by grinding the liquid with the carrier in a mortar. The carrier used in these experiments was talc. Previous to dusting, the apples were sprayed with water to cause the dust to adhere in an even film. All the materials mentioned in Table 2 were applied as dusts.

TRANSFERRING THE LARVAE. In agreement with an observation made by Smith (5) it was noted that the first larvae to hatch from a lot of eggs usually showed greater vigor than those which hatched last. The experimental results obtained do not, however, bring out any greater susceptibility of one lot of larvae than of another lot. Larvae hatching from eggs whose development had been retarded by being placed in cold temperature were less vigorous than those whose development had been unchecked.

The work was so arranged that only newly hatched larvae were used. No particular attention was paid to the length of time after the spray application until the larvae were placed on the apples except in the case of those sprays used as contact poisons. A small camel's-hair brush or a needle point was used in transferring the larvae. This was accomplished by having the larva attach its silk thread to the needle point or brush and gently lifting the larva in midair to the apple. The brush was kept soft and flexible by moistening it frequently. Considerable care was exercised to prevent injury to the larva and to place it ventral side down

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so that it could make contact with the surface of the apple with its legs. Five larvae were used to each apple and five apples to each test.

LABORATORY CONDITIONS. These studies were conducted in an open insectary where ventilation was easily controlled. This prevented rain or wind from interfering with the apples which were suspended.

DETERMINATION OF INJURY. The injury was recorded as of two forms. An entrance corresponds to the term "worm" commonly used in codling moth writings. Injury recorded as an "entrance" means that a larva has eaten through the skin of the apple and into the tissues without receiving a lethal dose of the poison. Injury recorded as a "sting" means that a larva attempted to enter the apple, but because of the effects of the poison or from other causes ceased eating after making a slight pit in the skin or, at most, a small excavation in the tissue of the apple. A feeding injury one-fourth inch or less in depth was recorded as a sting.

Nine days after the application of the larvae an incision approximately one-fourth inch deep was made under each injury. Any burrow which extended deeper than one-fourth inch was recorded as an "entrance." Injuries of less extent were considered "stings" unless the larvae were found alive. Most of the stings were so slight that they would have escaped notice on the surface of a growing apple. Observations indicated that only rarely would a larva make more than one injury. In this report it is considered that the number of injuries corresponds with the number of larvae making them.

RESULTS OF TESTS. In presenting the results of these tests in the tables, it has been necessary to give only the summary of all of the tests made with any given material. The total number of larvae used in each case is shown. The number of stings, the number of entrances, and the percentage of worms producing worm holes are recorded. The percentage of efficiency given for each material was calculated by the method described by Abbott (*1*). In all experiments untreated checks were run at the same time and in all of the tests comparison is made with powdered lead arsenate applied as a spray and as a dust; this being considered the standard treatment.

Variations in the percentage of entrances into the treated fruit as well as into the check fruit are to be expected and are unavoidable. This variation, however, should not affect the purpose of the experiments, since no attempt is being made in this preliminary survey of a large group of materials to draw conclusions from narrow differences.

CASEIN SPREADER. Several investigators have published results which showed that the addition of casein spreaders to insecticides either increased or did not decrease their efficiency. Lovett and Robinson (*2*) reported 50 per cent increase in effectiveness when casein spreader was used in orchard tests against the codling moth in 1918 and 1919. Stearns and Hough (*6*) reported no difference in results against the codling moth and other chewing insects. Newcomer (*3*) obtained slightly better control of the codling moth in the orchard with the spreader added to the lead arsenate than without, and from laboratory tests in 1923 and 1924 he reported that all tests with spreader gave better results than where no spreader was used. Similar tests were made at Moorestown, New Jersey, in 1927 and the results are shown in Table 1.

TABLE 1. COMPARISON OF THE EFFECTIVENESS OF DIFFERENT ARSENICALS AND FLUOSILICATES USED AS SPRAYS WITH AND WITHOUT CASEIN SPREADER AGAINST THE LARVA OF THE CODLING MOTH, MOORESTOWN, NEW JERSEY, 1927 AND 1928

In Amounts Equivalent to 1 Pound of Lead Arsenate to 50 Gallons of Water

Material	Number of larvae used	Number of stings	Number of entrances	Per cent entrances	Per cent efficiency
Aluminum arsenate; no spreader	150	12	96	64.0	21.6
Aluminum arsenate; casein spreader	100	16	58	58.0	29.0
Basic lead arsenate; no spreader	150	24	36	24.0	70.6
Basic lead arsenate; casein spreader	150	33	66	44.0	46.1
Calcium arsenate; no spreader	150	6	6	4.0	95.1
Calcium arsenate; casein spreader	150	18	66	44.0	46.1
Ferric arsenate; no spreader	150	21	72	48.0	41.2
Ferric arsenate; casein spreader	150	3	120	80.0	2.1
Magnesium arsenate; no spreader	150	24	102	68.0	16.7
Magnesium arsenate; casein spreader	150	9	120	80.0	2.1
Manganese arsenate; no spreader	150	15	66	44.0	46.1
Manganese arsenate; casein spreader	150	9	51	54.0	33.9
Paris green; no spreader	150	33	6	4.0	95.1
Paris green; casein spreader	150	27	10	20.0	75.5
Tricalcium arsenate; no spreader	150	36	18	12.0	85.3
Tricalcium arsenate; casein spreader	150	24	81	54.0	33.9
Zinc arsenate; no spreader	150	45	12	8.0	90.2
Zinc arsenate; casein spreader	150	15	90	60.0	26.5
Zinc arsenite; no spreader	150	15	72	48.0	41.2
Zinc arsenite; casein spreader	150	21	63	42.0	48.6
Barium fluosilicate; no spreader	200	42	27	13.5	83.4
Barium fluosilicate; casein spreader	150	27	45	30.0	63.2
Sodium fluosilicate; no spreader	150	9	42	28.0	65.7
Sodium fluosilicate; casein spreader	150	31	42	28.0	65.7
Acid lead arsenate ($PbHAsO_4$) no spreader	200	46	24	12.0	85.3
Acid lead arsenate ($PbHAsO_4$) casein spreader	175	29	84	48.0	41.2

IN AMOUNTS EQUIVALENT TO 2 POUNDS OF LEAD ARSENATE TO 50 GALLONS OF WATER

Material	Number of larvae used	Number of stings	Number of entrances	Per cent entrances	Per cent efficiency
Aluminum arsenate; no spreader	150	33	24	16.0	80.4
Aluminum arsenate; casein spreader	150	9	102	68.0	16.7
Basic lead arsenate; no spreader	150	27	6	4.0	95.1
Basic lead arsenate; casein spreader	150	21	42	28.0	65.7
Calcium arsenate; no spreader	150	39	18	12.0	85.3
Calcium arsenate; casein spreader	150	9	48	32.0	60.8
Ferric arsenate; no spreader	150	15	36	24.0	70.6
Ferric arsenate; casein spreader	150	6	78	52.0	36.3
Magnesium arsenate; no spreader	150	21	54	36.0	55.9
Magnesium arsenate; casein spreader	150	3	102	68.0	16.7
Manganese arsenate; no spreader	150	42	12	8.0	90.2
Manganese arsenate; casein spreader	150	24	24	16.0	80.4
Paris green; no spreader	150	45	0	0.0	100.0
Paris green; casein spreader	150	30	6	4.0	95.1
Tricalcium arsenate; no spreader	150	33	12	8.0	90.2
Tricalcium arsenate; casein spreader	150	9	6	4.0	95.1
Zinc arsenate; no spreader	150	18	30	20.0	75.5
Zinc arsenate; casein spreader	150	12	36	24.0	70.6
Zinc arsenite; no spreader	150	39	0	0.0	100.0
Zinc arsenite; casein spreader	150	27	18	12.0	85.3
Barium fluosilicate; no spreader	150	51	0	0.0	100.0
Barium fluosilicate; casein spreader	150	24	30	20.0	75.5
Acid lead arsenate ($PbHAsO_4$); no spreader	150	24	12	8.0	90.2
Acid lead arsenate ($PbHAsO_4$); casein spreader	150	44	46	30.6	62.5
Unsprayed (checks)	175	0	143	81.7	0.0

RESULTS. As will be noted in Table 1, the following materials were tested with and without calcium caseinate as a spreader: acid lead arsenate, aluminum arsenate, basic lead arsenate, calcium arsenate, ferric arsenate, magnesium arsenate, manganese arsenate, Paris green, tri-calcium arsenate, zinc arsenate, zinc arsenite, barium fluosilicate, and sodium fluosilicate. Each material was tested at the rate equivalent to 1 and 2 pounds of lead arsenate to 50 gallons of water. In the tests where calcium caseinate was employed as a spreader it was used at the recommended rate of one-eighth pound to 50 gallons water. Of the many tests made, those in which calcium caseinate had been added as a spreader to the mixture showed an increase in the percentage of entrances except in four instances. These exceptions were when aluminum arsenate was tested with and without the spreader at the 1-pound rate, zinc arsenate at the 1-pound rate, and tri-calcium arsenate when used at the 2-pound rate.

The data presented in Table 1 also show some materials which are rather high in toxicity. The materials giving the best results when used at the one pound rate are: Paris green, acid lead arsenate, calcium

arsenate, tri-calcium arsenate, barium fluosilicate, and zinc arsenate. Manganese arsenate and basic lead arsenate gave results of promise when the rate of application was increased to 2 pounds to 50 gallons water.

TESTS WITH MISCELLANEOUS CHEMICALS. Two hundred eighty-three materials in this group were tested in the laboratory against the codling moth. The chemicals were chosen with a view to include representative members from as many groups as possible with the definite object of finding some group or groups of compounds which might be useful. It was impossible to obtain members of certain groups, in others, only a few compounds were available. A study of the recent literature reporting work along similar lines revealed that all the work was done with insects other than the codling moth. A study was made of the various chemicals tested and of the insecticidal character of the various groups in so far as the data enabled one to make such a comparison. A list of the various chemical groups was prepared and an attempt was made to obtain several representatives from as many of the groups as possible. It was found impossible to purchase many of the chemicals originally selected for tests. Certain lists of chemicals carried in stock by dealers were then examined and compounds which were similar in character to those originally selected were purchased. The chemicals tested include representatives of as many of the groups as it was possible to obtain under the circumstances.

The materials numbered from 1 to 203, inclusive, in Table 2 were applied as dusts undiluted. The materials numbered from 208 to 280, inclusive, were liquids at ordinary temperatures and were applied by impregnating them in talc at the rate of 5 grams of the material to 45 grams of talc.

TABLE 2. RESULTS OF TESTS OF MISCELLANEOUS CHEMICALS APPLIED AS DUSTS AGAINST THE LARVA OF THE CODLING MOTH, MOORESTOWN, NEW JERSEY 1927 AND 1928

No.	Material	Number of larvae used	Number of stings	Number of entrances	Per cent entrances	Per cent efficiency
1	Acetamide	100	8	56	56.0	31.2
2	Acetanilide	50	1	42	84.0	0.0
3	Acetphenetidin	25	4	16	64.0	21.3
4	Acetyl diphenylamine	25	0	13	52.0	36.1
5	Acetyl p-anisidine	25	2	19	76.0	6.6
6	Acetyl p-aminobenzoic acid	25	0	25	100.0	0.0
7	Acetoxime	100	15	45	45.0	44.7
8	Acetyl-o-methyl toluidine	25	2	21	84.0	0.0
9	Acetyl n-propylaniline	175	19	31	17.7	78.2
10	dl-Alanine	150	7	81	54.0	21.3

TABLE 2.—*Continued*

No.	Material	Number of larvae used	Number of stings	Number of entrances	Per cent entrances	Per cent efficiency
11	Alloxantin	25	3	16	64.0	33.6
12	Allontoin	25	1	20	80.0	1.7
13	Aminoguanidine bicarbonate	25	5	17	68.0	16.4
14	p-Aminobenzoic acid	100	16	58	58.0	28.7
15	p-Aminoazobenzene	100	15	59	59.0	27.5
16	p-Aminophenol	25	5	11	44.0	45.9
17	p-Aminophenol oxalate	25	5	16	64.0	21.3
18	m-Aminophenol	25	2	14	56.0	31.2
19	Anthranilic acid	25	2	14	56.0	31.2
20	Antimony sulphide	150	7	111	74.0	9.0
21	Asparagin	25	0	23	92.0	0.0
22	l-Aspartic acid	25	0	18	72.0	15.5
23	Azobenzene	175	13	23	13.1	83.9
24	Azoxybenzene	175	30	15	8.5	89.5
25	Allyl urea	100	3	50	50.0	38.8
26	Acetoacetanilide	100	0	0	0.0	100.0
27	Barbituric acid	25	1	17	68.0	16.4
28	Barium fluoride	225	19	82	32.0	60.7
29	Barium hydroxide	125	14	75	50.0	38.5
30	Barium carbonate	150	6	78	52.0	36.1
31	Barium fluosilicate	200	13	7	3.5	95.7
32	Berberine bisulphate	150	25	65	42.7	47.4
33	Benzanilide	25	2	12	48.0	41.0
34	Benzeneazo-o-cresol	100	8	25	25.0	69.2
35	Benzenesulfonamide	25	3	19	76.0	6.6
36	Benzamide	100	9	38	38.0	53.3
37	Benzidine	125	10	66	52.8	35.1
38	Benzoyl o-toluidine	25	2	16	64.0	21.3
39	Benzoyl a-naphthylamine	25	4	17	68.0	14.4
40	Bismark brown	25	2	21	84.0	0.0
41	Borax	150	0	72	48.0	41.0
42	Brucine alkaloid	25	1	12	48.0	41.0
43	p-Bromobenzene sulfochloride	25	2	11	44.0	45.9
44	Brilliant green	25	3	13	52.0	36.1
45	n-Butylarsonic acid	100	11	13	13.0	84.0
46	Caffeine	25	1	18	72.0	15.5
47	Calcium borate	150	12	102	68.0	16.4
48	Calcium fluoride	150	9	51	34.0	58.2
49	Carbazole	125	20	23	18.4	77.4
50	Carbanilide	25	3	16	64.0	21.3
51	Cinchonine	25	5	13	52.0	36.1
52	Copper sulfocyanide	200	9	98	49.0	39.8
53	Copper carbonate	225	3	90	40.0	50.8
54	p-Chlorobenzonitrile	25	2	13	52.0	36.1
55	a-Chlorolepidine	100	5	37	37.0	54.5
56	b-Chloronaphthalene	100	10	13	13.0	84.0
57	Crysoidine	25	0	18	72.0	15.5
58	l-Cystine	100	4	53	53.0	34.9
59	Coniine hydrobromide	100	7	61	61.0	25.0
60	Dianisidine	25	0	16	64.0	21.3
61	Diazoaminobenzene	120	0	0	0.0	100.0
62	Dibemzoyl ethylenediamine	100	12	39	39.0	52.0
63	Dibromobarbituric acid	100	8	28	28.0	65.6
64	Dibenzylamine	25	8	12	48.0	41.0
65	Dichlorobarbituric acid	25	2	17	68.0	16.4
66	Dicyandiamidine sulfate	25	1	19	76.0	6.6

TABLE 2.—*Continued*

No.	Material	Number of larvae used	Number of stings	Number of entrances	Per cent entrances	Per cent efficiency
67	Dicyandiamidine	25	0	23	92.0	0.0
68	Dibromonaphthalene	100	24	0	0.0	100.0
69	Diethylbarbituric acid	100	9	32	32.0	60.7
70	p-Dimethylamino-phenol oxalate	100	17	9	9.0	88.9
71	2.4-Dinitrochlorobenzene	100	0	2	2.0	97.5
72	2.4-Dinitrophenol	100	0	0	0.0	100.0
73	3.5-Dinitro-o-cresol	100	0	0	0.0	100.0
74	2.4-Dinitrotoluene	100	4	1	1.0	98.7
75	2.4-Dimitroaniline	100	19	4	4.0	95.0
76	Di-b-naphthylamine	25	3	14	56.0	31.2
77	Dinitroresocinol	25	2	15	60.0	26.2
78	Di-o-nitrophenyl disulfide	25	0	24	96.0	0.0
79	2.6-Dinitro-4-chlorophenol	100	4	1	1.0	98.7
80	o-Dinitrobenzene	25	0	24	96.0	0.0
81	Diphenylpiperazine	100	11	16	16.0	80.3
82	4.4-Diphenylsemicarbazide	25	1	18	72.0	15.5
83	Diphenylformanidine	25	0	13	52.0	36.1
84	Diphenylguanidine	25	0	18	72.0	15.5
85	Diphenylethylenediamine	25	3	11	44.0	45.9
86	Diphenylamine	125	0	1	0.8	99.0
87	Diphenylurethane	100	3	14	14.0	82.8
88	Diphenylpiperzine hydrochloride	25	2	15	60.0	26.2
89	Diphenylcarbamine chloride	125	21	20	16.0	80.3
90	Di-p-toluene sulfamide	25	0	16	64.0	21.3
91	Di-o-tolyguanidine	25	3	11	44.0	45.9
92	Di-o-tolythiourea	100	4	52	52.0	36.1
93	2.5-Dichloroaniline	100	2	60	60.0	26.2
94	Ethylenediamine hydrobromide	25	4	13	52.0	36.1
95	Ethyl p-nitrobenzoate	25	5	14	56.0	31.2
96	Ethyl p-nitrocinnamate	25	2	21	84.0	0.0
97	Ethyl oxanilate	25	2	18	72.0	15.5
98	Formanilide	100	9	39	39.0	52.0
99	Guanidine carbonate	100	10	38	38.0	53.3
100	Guanidine thiocyanate	100	0	1	1.0	98.7
101	Histidine dichloride	25	3	20	80.0	1.7
102	Hydrazine sulfate	25	4	17	68.0	16.1
103	Hydrobenzamide	25	1	23	92.0	0.0
104	p-Hydroxyazobenzene	25	3	11	44.0	45.9
105	8-Hydroxyquinoline	100	4	16	16.0	80.3
106	Lead fluoride	250	8	70	28.0	65.6
107	Lead chromate	125	5	65	52.0	31.6
108	Lead borate	150	11	90	60.0	26.2
109	Lead formate	125	9	20	16.0	80.3
110	Lead oxalate	100	7	18	18.0	77.8
111	Lead salicylate	25	4	15	60.0	26.2
112	Lead thiosulfate	25	2	12	48.0	41.0
113	Magnesium fluoride	200	14	68	34.0	58.2
114	Magnesium borate	150	2	75	50.0	38.5
115	Manganese borate	200	2	58	29.0	64.3
116	Malachite green	100	4	19	19.0	76.6
117	Malonamide	25	1	20	80.0	1.7
118	Mercury sulfocyanate	125	32	2	1.6	98.0
119	Mercuric chloride	250	1	70	28.0	65.6
120	Metanilic acid	25	1	15	60.0	26.2
121	Methyl p-nitrobenzoate	25	3	20	80.0	1.7
122	a-Naphthylamine	100	2	8	8.0	90.1

TABLE 2.—*Continued*

No.	Material	Number of larvae used	Number of stings	Number of entrances	Per cent entrances	Per cent efficiency
123	b-Naphthylamine	25	3	15	60.0	26.2
124	b-Naphthyl salicylate	25	3	11	44.0	45.9
125	Nickel cyanide	125	0	90	72.0	15.5
126	Nickel borate	150	0	51	34.0	58.2
127	m-Nitrobromobenzene	25	4	17	68.0	16.4
128	p-Nitroaniline	125	15	48	38.4	52.8
129	3-Nitro-4-amino phenetole	100	7	44	44.0	45.9
130	3-Nitro-4-amino toluene	100	2	3	3.0	96.3
131	m-Nitroaniline	25	3	11	44.0	45.9
132	p-Nitroacetanilide	25	4	11	44.0	45.9
133	Nicotinic acid hydrochloride	25	0	19	76.0	6.6
134	o-Nitrobromobenzene	25	7	14	56.0	31.2
135	m-Nitrobenzaldehyde	100	9	29	29.0	64.3
136	p-Nitrobromobenzene	100	14	11	11.0	86.4
137	p-Nitrochlorobenzene	100	24	16	16.0	80.3
138	o-Nitrochlorobenzene	100	8	65	65.0	20.1
139	p-Nitrochlorobenzene	100	22	31	31.0	61.9
140	o-Nitrocinnamic acid	25	0	19	76.0	6.6
141	Nitroguanidine	25	2	19	76.0	6.6
142	a-Nitronaphthalene	125	9	1	0.8	99.0
143	Nitronaphthylamine	125	6	0	0.0	100.0
144	p-Nitrophenol	100	1	13	13.0	84.0
145	o-Nitrophenol	25	1	13	52.0	36.1
146	p-Nitrophenylglycine	100	1	69	69.0	15.2
147	6-Nitroquinoline	150	3	22	14.6	82.0
148	Nitrofluorene	100	0	57	57.0	29.9
149	Oxamide	25	0	23	92.0	0.0
150	Oxanilic acid	100	14	60	60.0	26.2
151	Oxanilide	25	1	20	80.0	1.7
152	Parabanic acid	25	0	23	92.0	0.0
153	p-Phenylenediamine	150	19	20	13.3	83.7
154	Phthalimide	100	0	54	54.0	33.6
155	Phenylurea	100	2	58	58.0	28.7
156	dl-Phenylalanine	25	7	13	52.0	36.1
157	Picric acid	100	8	61	61.0	25.0
158	Picramide	25	2	20	80.0	1.7
159	Picramic acid	25	0	15	60.0	26.2
160	Picryl chloride	25	0	23	92.0	0.0
161	Pilocarpine hydrochloride	25	5	11	44.0	45.9
162	Piperazine hydrate	100	9	12	12.0	83.4
163	Piperine	125	22	22	17.2	78.6
164	Potassium methyl xanthate	100	0	1	1.0	98.7
165	Potassium borate	125	5	75	60.0	38.5
166	Quinaldine	100	0	52	52.0	36.1
167	Quinolinic acid	25	0	19	76.0	6.6
168	Quinine alkaloid	25	2	18	72.0	15.5
169	Rosaniline hydrochloride	25	3	18	72.0	15.5
170	Sodium magnesium fluoride	100	4	44	44.0	45.9
171	Sodium fluosilicate	125	10	30	24.0	70.5
172	Sodium p-toluenesulfinate	25	2	22	88.0	0.0
173	Strychnine aklaloid	125	1	48	38.4	52.8
174	Strontium fluoride	200	8	72	36.0	55.7
175	Strontium borate	175	5	112	64.0	21.3
176	Sulfanilic acid	25	1	11	44.0	45.9
177	Tetramethyldiamino benzophenone	25	0	24	96.0	0.0

TABLE 2.—*Continued*

No.	Material	Number of larvae used	Number of stings	Number of entrances	Per cent entrances	Per cent efficiency
178	Tetramethyldiamino benzhydrol	25	0	20	80.0	1.7
179	Thioacetamide	25	2	13	52.0	36.1
180	Thioacetanilide	100	4	4	4.0	95.0
181	p-Toluenesulfonamide	25	1	14	56.0	31.2
182	p-Toluenesulfonyl - methyl - ptoluidine	25	1	20	80.0	1.7
183	p-Toluenesulfonyl methylaniline	25	0	21	84.0	0.0
184	p-Toluenesulfonyl - p - toluidine	100	4	47	47.0	42.2
185	p-Toluidine	25	3	19	76.0	6.6
186	Tribenzylamine	25	0	21	84.0	0.0
187	1.3.5-Trinitrobenzene	100	23	28	28.0	65.6
188	Trinitro-m-cresol	125	6	47	37.7	53.6
189	Triphenylguanidine	25	3	16	64.0	21.3
190	Triphenyl phosphine	100	6	15	15.0	81.5
191	Triphenylamine	100	4	58	58.0	28.7
192	Triphenylstibine	100	19	23	23.0	71.7
193	l-Tryosine	25	0	17	68.0	16.4
194	Urethane	25	3	19	76.0	6.6
195	n-Valeramide	100	6	31	31.0	61.9
196	Veratrine alkaloid	125	0	0	0.0	100.0
197	Zinc borate	175	2	77	44.0	45.9
198	Zinc cyanide	125	15	110	88.0	0.0
199	Zinc carbonate	200	6	92	46.0	43.4
200	Zinc fluoborate—Zinc oxide	25	1	8	32.0	60.7
201	Zinc oxalate	25	1	14	56.0	31.2
202	Zinc salicylate	50	3	13	26.0	68.0
203	Zinc sulfate	150	10	96	64.0	21.2
204	Acid lead arsenate	400	21	11	2.75	96.6
205	Checks	2,875	25	2,351	81.4	—
206	Acid lead arsenate 2–50	150	24	12	8.0	90.1
207	Acid lead arsenate 1–50	200	40	24	12.0	85.2
208	Acetate, Iso-amyl	100	13	36	36.0	55.7
209	Acetonitrile	100	3	44	44.0	45.9
210	Acetodichlorohydrin	25	3	13	52.0	36.1
211	Acetophenone	25	3	12	48.0	41.0
212	Alcohol, Iso-amyl	25	2	12	48.0	41.0
213	2-Amino-1.3-dimethylbenzene	175	19	53	30.2	62.9
214	n-Amylamine	175	7	80	45.7	43.8
215	Anisaldehyde	175	10	68	38.8	52.4
216	o-Anisidine	100	3	49	49.0	39.8
217	Benzonitrile	125	11	80	64.0	21.3
218	Benzoyl piperidine	100	3	23	23.0	71.7
219	Benzylamine	100	9	22	22.0	72.9
220	Benzylmethylamine	25	0	17	68.0	16.4
221	n-Butyl acetate	100	1	30	30.0	63.1
222	n-Butyl chlorocarbonate	100	7	40	40.0	50.8
223	di-n-Butylcyanamide	100	23	4	4.0	95.0
224	n-Butyl oxalate	25	1	23	92.0	0.0
225	n-Butyl thiocyanate	100	2	44	44.0	45.9
226	b-Chloroethyl-p-toluene sulfonate	100	1	2	2.0	97.5
227	a-Chloronaphthalene	100	6	31	31.0	61.9
228	Chloropicrin	100	1	31	31.0	61.9
229	o-Cresyl benzoate	100	2	15	15.0	81.5

TABLE 2.—*Concluded*

No.	Material	Number of larvae used	Number of stings	Number of entrances	Per cent entrances	Per cent efficiency
230	Cumidine	125	5	60	48.0	41.0
231	Cyanamide	100	4	3	3.0	96.3
232	Dibenzylamine	100	8	2	2.0	97.5
233	b.b′-Dichloroethyl carbonate	100	3	49	49.0	39.8
234	Dimethylaniline	100	13	36	36.0	55.7
235	Diethylaniline	115	15	40	26.6	67.3
236	Diethyl-o-toluidine	100	6	56	56.0	31.2
237	Dihydronaphthalene	100	8	49	49.0	39.8
238	Diethylamine	100	0	40	40.0	50.8
239	Discard oil (from bone oil)	175	9	46	26.2	67.8
240	Ethyl benzyl o-toluidine	125	10	6	4.8	94.3
241	Ethylaniline	25	5	12	48.0	41.0
242	Ethylamine	25	4	14	56.0	31.2
243	Ethylene cyanide	125	4	41	32.8	59.7
244	Ethyl cyamoacetate	100	1	52	52.0	31.6
245	Ethyl isothiocyanate	100	3	38	38.0	53.3
246	Ethyl methyl xanthate	25	2	13	52.0	31.6
247	Ethyl-a-naphthylamine	100	20	4	4.0	95.0
248	Ethyl thiocyanate	125	8	51	40.8	49.8
249	Iso-amylaniline	100	2	15	15.0	81.1
250	Iso-amyl chlorocarbonate	100	2	39	39.0	52.0
251	Iso-amyl formate	100	0	34	34.0	58.2
252	Iso-amyl nitrate	100	3	20	20.0	75.4
253	Iso-amyl nitrite	100	3	49	49.0	39.8
254	Iso-amyl oxalate	100	3	51	51.0	37.3
255	Iso-amyl phthalate	100	2	40	40.0	50.8
256	Iso-butyl n-butyrate	25	2	11	44.0	45.9
257	Iso-Propyl oxalate	100	3	32	32.0	60.7
258	Methylaniline	100	2	34	34.0	58.2
259	Methyl carbonate	100	1	22	22.0	72.9
260	Methyldiphenylamine	25	7	11	44.0	45.9
261	Methyl-a-naphthylamine	100	2	7	7.0	91.4
262	Nicotine	225	7	0	0.0	100.0
263	Nitrobenzene	100	25	34	34.0	58.2
264	Nitromethane	100	4	39	39.0	52.0
265	o-Nitrotoluene	100	3	12	12.0	85.2
266	Pentamethylene bromide	25	1	14	56.0	31.2
267	p-Phenetidine	25	4	12	48.0	41.0
268	Phenyl isocyanide	100	4	42	42.0	48.5
269	a-Picoline	100	2	29	29.0	64.3
270	Piperidine	100	6	19	19.0	76.6
271	n-Propyl p-toluene sulfonate	100	0	5	5.0	93.8
272	Pyridine	100	4	31	31.0	61.9
273	Quassia extract	100	1	50	50.0	38.8
274	Quinoline	225	21	59	22.6	72.2
275	Tetraethylammonium hydroxide	100	1	65	65.0	20.1
276	Tetramethylammonium hydroxide	100	14	16	16.0	80.3
277	p-Toluenesulphonyl-p-toluidine	100	8	32	32.0	60.7
278	Triethylamine	100	3	42	42.0	48.5
279	Trimethylamine	100	2	52	52.0	31.6
280	Tri-iso-amylamine	25	2	12	48.0	41.0
281	Talc (alone)	300	2	223	74.3	8.7

RESULTS

From the data presented in Table 2 it will be noted that many of the materials tested gave a high percentage of efficiency. Those materials which gave promising results when used undiluted were selected for further tests. The materials were divided into two groups, namely, liquids and powders. They are listed in Table 3 as follows: Numbers 1 to 36, inclusive, were powders and were diluted with talc at the rate of 5 grams of the material to 45 grams of talc, or a 10 per cent dust. Those materials listed under numbers 37 to 60, inclusive, were liquids at ordinary temperatures and were diluted with talc and applied as dusts at the rate of 5 grams of the material in 45 grams of talc.

TABLE 3. RESULTS OF TESTS OF MISCELLANEOUS CHEMICALS APPLIED AS 10 PER CENT DUSTS AGAINST THE LARVA OF THE CODLING MOTH, MOORESTOWN, NEW JERSEY, 1928

No.	Material	Number of larvae used	Number of stings	Number of entrances	Per cent entrances	Per cent efficiency
1	Azobenzene	200	8	37	37.0	77.7
2	Azoxybenzene	200	0	86	43.0	48.3
3	Acetyl n-propylaniline	100	4	24	24.0	71.1
4	n-Butylarsonic acid	175	5	19	10.8	87.0
5	Benzamide	175	5	43	24.6	70.4
6	Benzeneazo-o-cresol	175	3	66	37.7	54.7
7	Carbazole	275	15	68	24.7	70.4
8	b-Chloronaphthalene	175	4	92	52.5	36.9
9	Dibromonaphthalene	150	4	24	16.0	80.7
10	Diphenylcarbamine chloride	275	12	53	30.2	63.7
11	2.6 Dinitro-4-chlorophenol	275	10	68	24.7	70.4
12	Diphenylurethane	275	10	41	14.9	82.1
13	Dimethylamino phenol oxalate	275	1	47	17.0	79.6
14	Diphenylpiperazine	75	0	45	59.9	28.0
15	Diazoaminobenzene	275	5	106	38.5	53.7
16	Dibromobarbituric acid	275	3	58	21.0	74.7
17	2.4-Dinitroaniline	175	1	68	38.5	53.7
18	Diphenylamine	275	1	9	3.2	96.1
19	2.4-Dinitrochlorobenzene	175	20	60	34.2	58.9
20	2.4-Dinitrotoluene	75	0	1	1.3	98.4
21	2.4-Dinitrophenol	75	0	0	0.0	100.0
22	3.5-Dinitro-o-cresol	75	0	0	0.0	100.0
23	8-Hydroxyquinoline	175	1	98	56.0	32.7
24	Lead formate	175	3	106	62.8	24.6
25	Mercury sulfocyanate	175	32	26	14.8	82.2
26	Malachite green	75	8	17	22.6	72.8
27	p-Nitrochlorobenzene	265	36	60	22.6	72.8
28	a-Naphthylamine	75	0	0	0.0	100.0
29	6-Nitroquinoline	275	23	99	36.0	68.7
30	a-Nitronaphthalene	275	21	24	87.3	0.0
31	3-Nitro-4-amino-toluene	175	3	86	49.1	39.8
32	Nitronaphthylamine	175	14	34	19.4	76.7
33	m-Nitrobenzaldehyde	175	11	66	37.7	54.7
34	Triphenylamine	100	19	30	30.0	63.9
35	n-Valeramide	275	0	130	47.2	43.3
36	Veratrine alkaloid	75	0	7	9.3	88.8

TABLE 3.—*Continued*

No.	Material	Number of larvae used	Number of stings	Number of entrances	Per cent entrances	Per cent efficiency
37	Anisaldehyde	100	5	23	23.0	72.3
38	n-Amylamine	100	3	18	18.0	77.9
39	2-Amino-1.3-dimethylbenzene	100	0	40	40.0	51.9
40	Benzylamine	175	0	82	46.6	46.2
41	n-Butyl acetate	175	5	57	32.6	60.8
42	di-n-Butyl cyanamide	175	26	41	23.4	71.5
43	Benzoyl piperidine	175	5	37	21.1	74.2
44	n-Butyl thiocyanate	175	2	103	58.9	29.3
45	b-Chloroethyl-p-toluene sulfonate	170	0	0	0.0	100.0
46	a-Chloronaphthalene	275	14	159	57.9	30.5
47	o-Cresyl benzoate	175	5	52	29.7	64.3
48	Diethylaniline	175	0	106	60.6	27.2
49	Disacrd oil (from bone oil)	100	6	27	27.0	67.5
50	Ethyl a-naphthylamine	175	11	32	18.3	77.8
51	Ethyl benzyl o-toluidine	175	9	35	20.0	75.9
52	Methyl carbonate	175	4	54	30.8	64.6
53	Methyl a-naphthylamine	175	6	76	43.4	47.9
54	o-Nitrotoluene	175	0	130	74.4	10.7
55	Pyridine	175	1	86	49.2	40.9
56	a-Picoline	175	4	92	52.6	36.8
57	Piperidine	100	0	39	39.0	53.1
58	Quinoline	175	5	80	45.7	45.1
59	Tetraethylammonium hydroxide	175	1	103	58.9	29.2
60	Tetramethylammonium hydroxide	100	6	33	33.0	60.4
61	Acid lead arsenate (Dust)	175	7	2	1.1	98.6
62	Checks	1,775	17	1,480	83.38	—
63	Quinoline emulsion (10)	200	10	128	64.0	23.1
64	a-Chloronaphthalene emulsion (10)	100	4	36	36.0	68.7

RESULTS. The most effective materials tested against the codling moth are listed below. Only those materials whose per cent efficiency is 70 or more are given. The values of these materials are taken from Table 2 and not Table 3. It should be distinctly understood that these materials have not been tested under a wide range of conditions. Further tests will be necessary to determine if any of them can be used in a practical way under field or orchard conditions.

Although the records are not complete owing to the authors having been transferred to other work, it is hoped that the data reported herein will form a basis for a continuation of this search for a practical arsenical substitute.

TABLE 4. THE MOST EFFECTIVE MATERIALS TESTED AGAINST LARVAE OF THE CODLING MOTH AS SUBSTITUTES FOR LEAD ARSENATE

Material	Per cent of efficiency
Acetyl n-propylaniline	78.2
Azobenzene	83.9
Azoxybenzene	89.5
Acetoacetanilide	100.0

TABLE 4.—*Continued*

Material	Per cent of efficiency
Barium fluosilicate	95.7
n-Butylarsonic acid	84.0
Carbazole	77.4
b-Chloronaphthalene	84.0
Diazoaminobenzene	100.0
Dibromonaphthalene	100.0
p-Dimethylamino phenol oxalate	88.9
2.4-Dinitrochlorobenzene	97.5
2.4-Dinitrophenol	100.0
3.5-Dinitro-o-cresol	100.0
2.4-Dinitrotoluene	98.7
2.4-Dinitroaniline	95.0
2.6-Dinitro-4-chlorophenol	98.7
Diphenylpiperazine	80.3
Diphenylamine	99.0
Diphenylurethane	82.8
Diphenylcarbamine chloride	80.3
Fluoricide (7.5)	72.9
Guanidine thiocyanate	98.7
8-Hydroxyquinoline	80.3
Lead formate	80.3
Lead oxalate	77.8
Malachite green	76.6
Mercury sulfocyanate	98.0
a-Naphthylamine	90.1
3-Nitro-4-amino toluene	96.3
m-Nitrobenzaldehyde	86.4
p-Nitrobromobenzene	80.3
a-Nitronaphthalene	99.0
Nitronaphthylamine	100.0
p-Nitrophenol	84.0
6-Nitroquinoline	82.0
p-Phenylenediamine	83.7
Piperazine hydrate	83.4
Piperine	78.6
Potassium methyl xanthate	98.7
Sodium fluosilicate	70.5
Thioacetanilide	95.0
Triphenyl phosphine	81.5
Triphenylstibine	71.7
Veratrine alkaloid	100.0
Benzoyl piperidine	71.7
Benzylamine	72.9
di-n-Butylcyanamide	95.0
b-Chloroethyl-p-toluene sulfonate	97.5
o-Cresyl benzoate	81.5
Cyanamide	96.3
Dibenzylamine	97.5
Ethyl benzyl o-toluidine	94.3
Ethyl-a-naphthylamine	95.0
Iso-amylaniline	81.1
Iso-amyl nitrate	75.4
Methyl carbonate	72.9
Methyl-a-naphthylamine	91.4
Nicotine (95)	100.0
o-Nitrotoluene	85.2
Piperidine	76.6
n-Propyl p-toluene sulfonate	93.8
Quinoline	72.2
Tetramethylammonium hydroxide	80.3

SUMMARY. In an investigation having as its object the discovery of a poison for codling moth control suitable for application in place of lead arsenate, many organic compounds were tested. A total of 283 materials other than lead arsenate are reported in this paper.

The tests were made by thoroughly applying the material to apples on which newly hatched codling moth larvae were placed. The coating of the material on the apple was of such a nature that the insect was unable to reach any portion of the apple without first going through the poison coat. A total of 46,960 newly hatched larvae were used in conducting the tests.

About 50 of all the materials tested as arsenical substitutes show an efficiency of 70 per cent or better and have been selected as worthy of further trial.

No attempt has been made to utilize any of these materials mentioned in the above paragraph in a practical way. The results herein reported deal strictly with the effectiveness of the compounds and mixtures tested for preventing entrance of codling moth larvae into treated apples under the conditions of the experiments.

LITERATURE CITED

1. ABBOTT, W. S. 1925. A Method of Computing the Effectiveness of an Insecticide. Jour. Econ. Ent. 18: 265–267.
2. LOVETT, A. L., and ROBINSON, R. H. 1917. Toxic Values and Killing Efficiency of the Arsenates. Jour. Agr. Res. 10: 199–207.
3. NEWCOMER, E. J. 1923. Codling Moth Control in Washington. Wash. State Hort. Proc. (1922) 18: 39–44.
4. NEWCOMER, E. J. 1926. Laboratory Experiments with Arsenicals in the Control of the Codling Moth. Jour. Agr. Res. 33: 317–330.
5. SMITH, R. H. 1926. The Efficacy of Lead Arsenate in Controlling the Codling Moth. "Hilgardia," Cal. Agr. Exp. Sta., Vol. 1, No. 17.
6. STEARNS, L. A., and HOUGH, W. S. 1923. Spreader Tests on Apples and Peaches. Jour. Econ. Ent. 16: 198–201.

FURTHER RESULTS WITH TRAP BAITS FOR CAPTURING THE CODLING MOTH[1]

By M. A. YOTHERS, *Associate Entomologist, Bureau of Entomology, United States Department of Agriculture*

ABSTRACT

The fifth year's tests were made in 1928 with trap baits for capturing the codling moth, *Carpocapsa pomonella* L. A severely infested orchard was used this season. Comparisons of various baits and their dilutions were made, and the use of bread and wild yeasts for starting fermentation, and of boric acid for preventing it. A comprehensive test made to determine the most efficient number of traps showed that the number of moths captured per trap increased with the number of trees from which moths could be attracted, but not in direct ratio.

Experiments with trap baits for capturing the codling moth in 1928 were conducted in four different orchards, but for the purposes of this paper the results in only one, the A. B. Haueter orchard, are discussed.

The Haueter orchard consisted of 5 acres of large, 30-year-old apple trees of several varieties. The tract had been neglected not only in 1928 but in previous seasons so the accumulated infestation was un-

TABLE 1. NUMBER OF CODLING MOTHS CAPTURED IN TRAP BAITS, HAUETER ORCHARD, YAKIMA, WASH., 1928; TEST NO. 1 (JULY 24–AUGUST 17)

Material	Total number of moths in—Dilution 1–10	Total number of moths in—Dilution 1–20	Average number of moths per trap-day in—Dilution 1–10	Average number of moths per trap-day in—Dilution 1–20
Malt syrup+bread yeast, 10 traps	1,594	1,460	13.28	12.17
Malt syrup+wild yeast, 10 traps	971	846	8.09	7.05
Cane molasses+bread yeast, 10 traps	1,793	1,394	14.94	11.62
Cane molasses+wild yeast, 10 traps	1,661	1,030	13.84	8.58
Beet molasses+bread yeast, 10 traps	855	931	7.13	7.76
Beet molasses+wild yeast, 10 traps	1,759	984	14.66	8.20
Cane molasses+boric acid, ¾ lb. per 10 qts. of bait, 10 traps	487	129	4.06	1.08
Beet molasses+boric acid, ¾ lb. per 10 qts. of bait, 10 traps	909	368	7.58	3.07

Material	Total number of moths	Average number of moths per trap-day
Apple ferment containing ¾ lb. brown sugar to 3 gallons of diluted apple juice, 10 traps	1,720	7.17
Brown sugar ¾ lb. to 3 gallons of water, 10 traps	2,007	8.36
Brown sugar ¾ lb. to 3 gallons water+geraniol 20 drops to a qt., 9 traps	2,759	12.76
Beet molasses 1–10 (check), 7 traps	1,146	6.82
Cane molasses 1–10 (check), 4 traps	1,134	11.81

[1]Yothers, M. A. Summary of Three Years' Tests of Trap Baits for Capturing the Codling Moth. JOUR. ECON. ENT. 20, p. 567, 1927.

Yothers, M. A. Summary of Results Obtained with Trap Baits in Capturing the Codling Moth in 1927. JOUR. ECON. ENT. 23, p. 576, 1930.

usually severe. This season the trees had been sprayed a couple of times, in an indifferent manner, for the spring brood only, consequently a great many moths were present when the traps were installed July 24.

Each trap in this test consisted of a 3-pint enameled kettle suspended by a seine cord run through a screw eye inserted in a cross arm at the top of a tree prop in the center of a tree. Ten rows of 13 to 14 trees each had a trap in each tree; beyond that traps were placed in every alternate tree in rows 11, 12, 14, 18, 21, 24, and 25. A total of 171 traps were operated from July 24 to September 6, and 143 from that date to September 14.

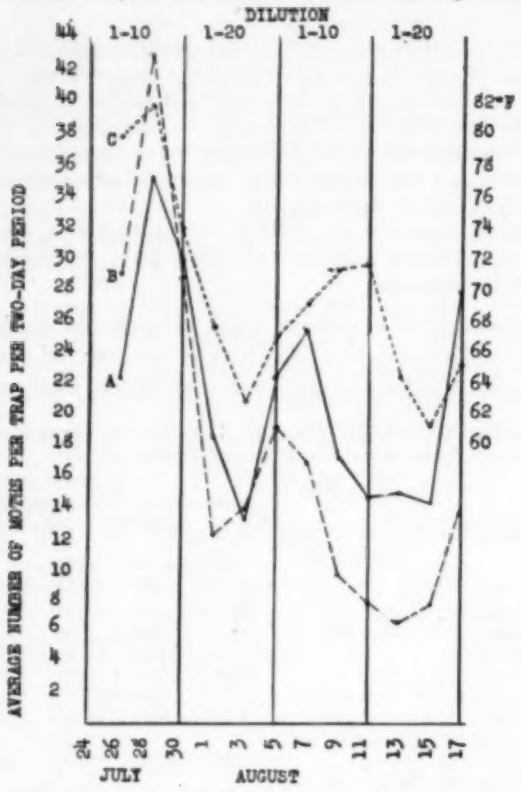

FIG. 73.—A comparison of dilutions of 1–10 and 1–20 of several kinds of codling moth baits, and the relation of temperature to the number of moths captured. A, Malt syrup, cane molasses, and beet molasses, each with bread and wild yeast added (grouped together); B, combined checks of constant 1-10 dilutions of cane molasses and beet molasses; C, average mean temperature from 6 P. M. to 12 midnight for the two days preceding date of record.

In Test No. 1 ten traps, one to a tree, were used for each material except the brown sugar+geraniol which had 9, and the checks, which had 7 for the beet molasses and 4 for the cane molasses. The test ran from July 24 to August 17. The bait materials in the first group were diluted 1 part to 10 parts of water for the first 6-day period, 1–20 for the second 6-day period, 1–10 again for the third, and 1–20 again for the fourth period. Malt syrup, cane molasses, and beet molasses, each with bread and wild yeast added, and cane molasses and beet molasses

each with boric acid added to prevent fermentation, were compared. A dilution of 1–20 in every case but one (beet molasses + bread yeast) was apparently less effective than a dilution of 1–10; however, this difference is largely minimized by corresponding variations in temperature (Fig. 73) in each of the 6-day periods. Concurrent comparisons of dilutions of these and other baits, however, indicate that the 1–10 dilution was usually somewhat more efficient than any greater dilution. From a comparison of these bait materials—malt syrup, cane molasses, and beet molasses—there appeared to be but little difference in their attractive value. Malt syrup appeared to be more attractive when bread yeast was added than when wild yeast[2] was added, whereas cane

TABLE 2. NUMBER OF CODLING MOTHS CAPTURED IN TRAP BAITS, HAUETER ORCHARD, YAKIMA, WASH., 1928; TEST NO. 2 (AUGUST 17, 1929)

Material and dilution	Total number of moths in— Dilution 1–10	1–20	Average number of moths per trap-day in— Dilution 1–10	1–20
Beet molasses+bread yeast left from previous tests, 10 traps	707	356	11.78	5.93
Malt syrup+bread yeast left from previous tests, 10 traps	970	517	16.17	8.62
Cane molasses+bread yeast left from previous tests, 10 traps	748	353	12.47	5.89
Beet molasses+wild yeast, 10 traps	443	282	7.38	4.70
Cane molasses+wild yeast, 10 traps	469	306	7.82	5.10
Beet molasses (check) 1–10, 7 traps	448	204	10.67	4.86
Cane molasses (check) 1–10, 4 traps	313	135	13.04	5.63

	Total number of moths	Average number of moths per trap-day
Geraniol and water, 20 drops to a qt., 10 traps	131	2.18
Geraniol and beet molasses, 20 drops to a qt., 10 traps	380	6.33
Geraniol and cane molasses, 20 drops to a qt., 10 traps	312	5.20
Geraniol and brown sugar, ¾ lb. to 3 gallons, 10 traps	319	5.32
Brown sugar, ¾ lb. to 3 gallons, 10 traps	375	6.25
Apple ferment 1 to 3 parts of water, 9 traps	138	2.56
Brown sugar, 1½ lbs. to 10 qts. water, 10 traps	234	3.90
Geraniol and brown sugar, 10 traps	377	6.28
Beet molasses 1–5, 10 traps	194	3.23
Malt syrup 1–32, 10 traps	210	3.50
Apple ferment 1 to 2 parts of water, 9 traps	146	2.70
One-half apple floated in water, 5 traps	6	.30
One-half apple floated in brown sugar (1 lb. to 5 qts.), 5 traps	61	3.05

[2]These wild yeasts were produced from spontaneous fermentation in tests in another orchard and brought over for use here by C. R. Gross of the Bureau of Chemistry.

molasses was apparently about as effective with one as with the other, but beet molasses was more attractive when it was inoculated with wild yeast than when bread yeast was added. The addition of boric acid to cane and beet molasses to prevent fermentation prevented a great many moths from entering these baits, but considerable numbers were caught nevertheless.

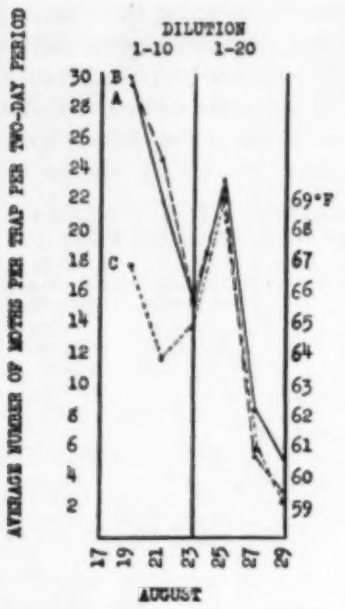

FIG. 74.—A comparison of dilutions of 1–10 and 1–20 of several kinds of codling moth trap baits, and the relation of temperature to the number of moths captured. A, Malt syrup, cane molasses, and beet molasses each with bread yeast and wild yeast added (grouped together); B, combined checks of constant 1–10 dilutions of cane molasses; C, average mean temperature from 6 P. M. to 12 midnight for the two days preceding the date of record.

In this same test additional materials were compared, all of which were comparable with one another and with those of the first group. Apple ferment, brown sugar, and brown sugar + geraniol were compared with two checks consisting of 7 traps of beet molasses and 4 traps of cane molasses, both of which were renewed with new bait every two days throughout the season. Apple ferment, made with ¼ lb. of brown sugar to 3 gallons of diluted apple juice, caught fewer moths than did the same quantity of brown sugar to 3 gallons of water containing no apple juice. The addition of geraniol to brown sugar increased its attractiveness over 50 per cent. The beet molasses check averaged 6.82 moths per trap-day while the cane molasses averaged 11.81.

In Test No. 2, a comparison of beet molasses, malt syrup, and cane molasses each with bread yeast left in the traps from previous tests, the malt syrup was the most effective, cane molasses next, and the best molasses last, but the difference was not significant. The test ran from August 17 to August 29, a 6-day period for each dilution, as in Test No, 1, for the first two groups, a 6-day period for the third and fourth groups. and a 4-day period for the last group. Again the 1–20 dilution seemed to be less attractive, but reference to Figure 74 shows that there is a

corresponding decrease in temperature which greatly counteracts this difference. Cane molasses and beet molasses with bread yeast added caught far more moths than where chance inoculation by wild yeast was depended upon. Both cane molasses and beet molasses caught fewer moths with chance inoculation by wild yeast than these two materials did in the checks where bread yeast was accumulating indefinitely. In additional tests, which are not comparable with the rest of the table, geraniol was found the least effective when added to water only, and most effective when added to beet molasses or brown sugar and water. Comparing brown sugar, brown sugar and geraniol, beet molasses 1–5, malt syrup 1–32, apple ferment, one-half apple floated in water, and one-half of an apple floated in brown sugar and water, the half apple floated in water was the least effective, capturing only 6 moths.

TABLE 3. NUMBER OF CODLING MOTHS CAPTURED IN TRAP BAITS, HAUETER ORCHARD, YAKIMA, WASH., 1928; TEST NO. 3 (AUGUST 29–SEPTEMBER 4)

Material	Dilution	Total number of moths	Average number of moths per trap-day
Apple ferment + new yeast and 1 lb. brown sugar to 3 gallons (10 traps)	—	407	6.78
Brown sugar, 1 lb. to 10 qts. water (10 traps)	—	485	8.08
Geraniol + brown sugar, 1 lb. to 10 qts. water (10 traps)	20 drops per qt. of water	528	8.80
Beet molasses, wild yeast retained (10 traps)	1–10	398	6.63
Cane molasses, wild yeast retained (10 traps)	1–10	509	8.48
Beet molasses + bread yeast (10 traps)	1–10	275	4.58
Malt syrup + bread yeast (10 traps)	1–10	313	5.22
Cane molasses + bread yeast (10 traps)	1–10	302	5.03
Beet molasses + bread yeast (10 traps)	1–5	303	5.05
Cane molasses + bread yeast (10 traps)	1–30	169	2.82
Check. Beet molasses (7 traps)	1–10	174	4.14
Check. Cane molasses (4 traps)	1–10	155	6.46

In another series of tests the most attractive bait of all was the brown sugar and geraniol combination, which captured an average of 8.80 moths per trap-day, while brown sugar alone caught an average of 8.08, and apple ferment, 6.78. Cane molasses, with wild yeast retained in the trap, averaged 8.48 moths per trap-day compared with an average of 6.63 for the beet molasses, also with wild yeast. Malt syrup, cane molasses, and beet molasses with bread yeast added, averaged respectively, 5.22, 5.03 and 4.58 moths per trap-day. Beet molasses 1–5 caught a few more moths than at the regular 1–10 dilution, whereas cane molasses 1–30 caught only an average of 2.82 moths per trap-day compared with 5.03 at the 1–10 strength.

A test was made to determine the most efficient number of traps. (Table 4.) It was found that the catch per trap increased with the

number of trees from which moths could be attracted, but not in direct ratio. Seven traps in 7 trees averaged 6.28 moths per trap-day for 46 days, 7 traps in 13 trees (2 cases) averaged 12.17 and 13.66 respectively, and 6 or 7 traps to 26 to 40 trees in rows 18 to 24 averaged about 23 + moths per trap-day. Seven traps in 13 trees in the last, outside row, averaged 36.65 moths, or about 3 times as many as were caught in row 10 with the same number of traps and trees. This was probably largely due to the fact that more moths are almost invariably captured in outside rows of baited plats. Judging from this test alone, and aside from the matter of expense, in order to secure the maximum catch per trap, one should allow not more than two trees per trap.

That great numbers of codling moths can be captured in trap baits in severely infested orchards is indicated in Table 5, which shows that 91,836 moths were captured in less than 171 traps from July 24 to September 14.

TABLE 4. NUMBER OF CODLING MOTHS CAPTURED IN TRAP BAITS WITH VARYING NUMBERS OF TREES ADJACENT FROM WHICH TO DRAW; HAUETER ORCHARD, YAKIMA, WASH., 1928

Row No.	Number of codling moths captured	Number of traps	Number of trees adjacent	Average number of moths per trap-day for 46 days	Remarks
9	2,023	7	7	6.28	Center of orchard
10	3,920	7	13	12.17	
11	4,400	7	13	13.66	
12	5,109	7	19	15.87	
14	5,215	6	31	18.89	
18	7,608	7	40	23.63	Rows 19 to
21	6,472	6	40	23.45	24 very
24	6,447	6	26	23.36	light crop
25	11,801	7	13	36.65	Outside row

TABLE 5. NUMBER OF CODLING MOTHS CAPTURED IN TRAP BAITS; HAUETER ORCHARD, YAKIMA, WASH., 1928

Date	Number of moths	Date	Number of moths
July 26	5,738	Aug. 21	5,171
28	7,191	23	3,644
30	6,592	25	5,158
Aug. 1	3,101	27	2,101
3	2,194	29	1,126
5	4,459	31	2,294
7	5,305	Sept. 2	3,216
9	5,178	4	3,200
11	3,865	6	2,078[1]
13	3,005	8	492
15	3,194	10	793
17	5,661	12	470
19	6,588	14	22
Total			91,836

[1]171 bait pots used in this and all preceding counts; 143 thereafter.

That large numbers of moths may be caught in single traps is indicated in Table 6, which shows that 3,111 moths were caught in a single trap during the 42 nights from July 24 to September 3 inclusive. This trap was at the corner of the experimental tract, but with another orchard adjoining on one side.

TABLE 6. RECORD OF A SINGLE TRAP CAPTURING THE LARGEST KNOWN NUMBER OF CODLING MOTHS; HAUETER ORCHARD, YAKIMA, WASH., 1928
(Trap No. 7, Row 25)

Date	Number of moths captured
July 26	60
28	131
30	205
Aug. 1	130
3	53
5	180
7	201
9	216
11	218
13	145
15	175
17	130
19	237
21	276
23	160
25	200
27	93
29	21
31	53
Sept. 2	85
4	142
Total	3,111
Number of nights	42
Average number of moths per night	74.07

SUMMARY

Of the several kinds of baits compared, malt syrup, cane molasses, beet molasses, and brown sugar and geraniol were the more promising.

Dilutions of 1–10 are probably only slightly more efficient for most of these baits than dilutions of 1–20.

Variations in temperature had greater effect upon the number of moths captured than the dilution of materials had.

Geraniol added to brown sugar and water and to beet molasses increased their effectiveness.

In a comparison of the effectiveness of bread yeast with wild yeast added to baits, the results were too variable to warrant conclusions one way or another.

The catch of moths per trap increased with the number of trees available from which to attract them, but not in direct ratio.

Great numbers of moths can be captured with bait traps in badly infested orchards.

A COMPARISON OF UNTREATED BANDING MATERIALS FOR CAPTURING CODLING MOTH LARVAE

By M. A. YOTHERS, *Associate Entomologist, Bureau of Entomology, United States Department of Agriculture. Yakima, Wash.*

ABSTRACT

In comparative tests of several kinds of untreated bands for capturing the larvae of the codling moth (*Carpocapsa pomonella* L.) at Yakima, Wash., a paper-burlap band proved equal or superior to one of burlap, which is customarily used, and is much less expensive. Heavy roofing paper and light crêpe paper were the least effective of the banding materials.

In an unsprayed block in 1927, bands averaged from 167 to 258 larvae per band for the season. In 1928 in another unsprayed orchard, bands averaged from 336 to 1,322 larvae per band for the period July 10 to November 14.

In 1927 and 1928 tests were made to determine the relative efficiency of several kinds of untreated bands for trapping codling moth larvae on the trunks of apple trees.

DESCRIPTION OF MATERIALS. Three-ply burlap bands were made by folding single-thickness burlap 1 foot in width twice, making a three-ply burlap band 4 inches wide. Single thickness burlap 8 inches wide was folded once, making a 2-ply band 4 inches in width. In one test the 2-ply burlap was 6 inches wide after folding. A commercial material was used which had been made by fastening together a layer of tough paper and a layer of thin burlap with a light—and water proof coating between them. This was used 8 and 4 inches wide, single thickness, and 4 and 2 inches wide after folding to two thicknesses. The crêpe paper, of medium weight and light color, was cut 4 inches wide and was applied as a single thickness. The roofing paper was a heavy grade of asphalt paper, 4 inches wide and so stiff that it was impossible to fit it snugly to trunks presenting appreciable irregularities.

All bands of more than a single thickness were applied with the open edge down.

SIEGERT ORCHARD, 1927. A severely infested unsprayed block of 58 Winesap trees was banded on June 23, 1927. The trees were more or less stunted in growth and ranged in size of trunk from about 6 to 12 inches in diameter. The crop of apples on the trees ranged from one-half bushel to about 15 bushels, none of which, however, was harvested on account of almost total infestation. The trunks were scraped and all of the rough bark removed before the bands were applied. The 58 trees consisted of 8 rows of from 7 to 8 trees each.

The season's experiment was divided into two series of tests, one running from June 23 to Sept. 7, and the other from Sept. 7 to Oct. 28.

The difference between the two tests was that the location of the kinds of bands was changed as to their position in the orchard. This shift was made for the purpose of reducing the influence of all variables as far as possible.

In Table 1 is shown the average number of larvae captured per band and the ranking according to effectiveness regardless of several variable factors. From one to three trees in each row in all but two of the rows, caught so few larvae that they should probably not be averaged in with the others, but since no record of size of crop on these trees was made, they have not been eliminated as aberrant.

TABLE 1. NUMBER OF CODLING MOTH LARVAE CAPTURED UNDER UNTREATED BANDS. SIEGERT ORCHARD. YAKIMA, WASH., 1927

Plat	Material	No. trees	No. larvae caught	Average No. of larvae per band	Rank
	Test I (June 23–Sept. 7)				
A	8-inch paper-burlap, single thickness*	7	1,300	186	6
B	4-inch paper-burlap, 2-ply	8	1,969	246	2
C	4-inch paper-burlap, single thickness	7	1,683	240	3
D	2-inch paper-burlap, 2-ply	8	1,496	187	5
E	4-inch crêpe paper, single thickness	7	1,119	160	7
F	4-inch roofing paper, single thickness	7	963	138	8
G	4-inch burlap, 3-ply	7	2,115	302	1
H	4-inch burlap, 2-ply	7	1,618	231	4
	Total	58	12,263		
	Test II (Sept. 7–Oct. 28)				
H	4-inch burlap, 2-ply	7	985	141	8
G	4-inch burlap, 3-ply	8	1,715	214	4
F	4-inch roofing paper, single thickness	7	1,367	195	6
E	4-inch crêpe paper, single thickness	8	1,605	201	5
D	2-inch paper-burlap, 2-ply	7	1,345	192	7
C	4-inch paper-burlap, single thickness	7	1,629	232	3
B	4-inch paper-burlap, 2-ply	7	1,748	250	2
A	8-inch paper-burlap, single thickness	7	2,235	319	1
	Total	58	12,629		

*In Figure 75, for convenience in labeling, single thickness is designated as "flat."

DISCUSSION OF RESULTS. In this test the 4-inch, 3-ply burlap caught the greatest average, 302 larvae per band (Fig. 75). The 4-inch paper-burlap, 2-ply, averaged 246; and the 4-inch paper-burlap, single thickness averaged 240; while the 4-inch single thickness roofing paper was the least effective, averaging only 138, and the 4-inch single thickness crêpe paper next to the poorest, averaging 160.

On Sept. 7 the rows of bands were transposed to the positions shown in Table 1, Test 2. In this test the 8-inch paper-burlap, single thickness, was the best, averaging 319 larvae per band; the same material, 4 inches wide, 2-ply, averaged 250 and the same material 4 inches wide and

single thickness, averaged 232. The three least efficient materials were: 4-inch burlap, 2-ply, averaging 141; 2-inch paper-burlap, 2-ply, averaging 192; and 4-inch roofing paper, averaging, 195.

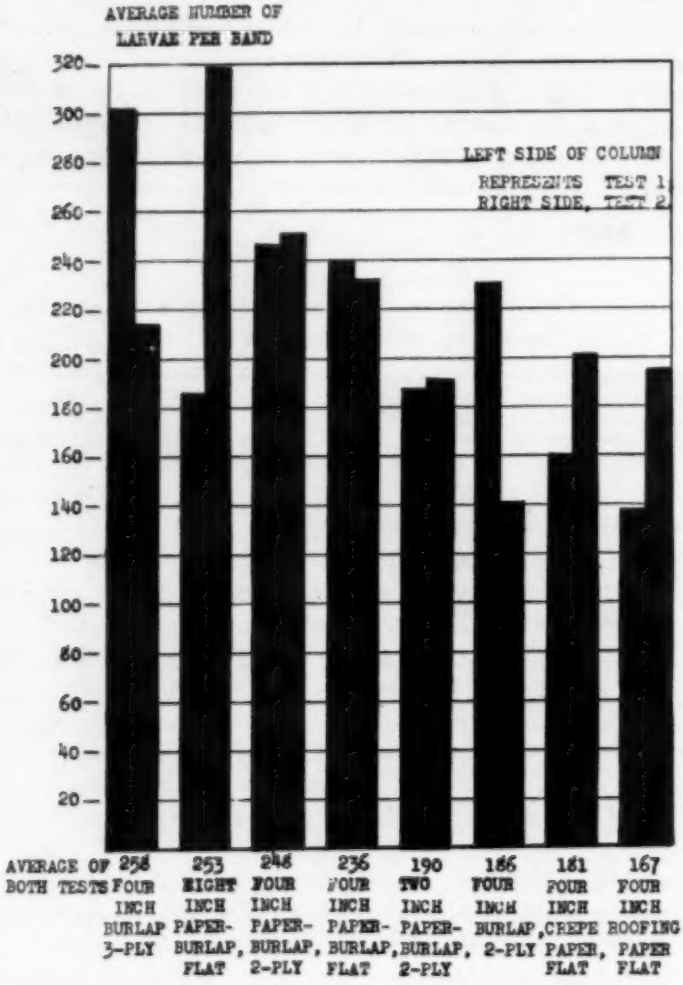

FIG. 75.—Average number of codling moth larvae caught in untreated bands, Siegert orchard, Yakima, Wash., 1927. Left side of column, Test 1, June 23 to Sept. 7; right side of column, Test 2, Sept. 7 to Oct. 28.

Obviously field heterogeneity played an important part in the results in the two preceding tests as indicated by the change of rank of effectiveness of the several items due to change of location in the plat.

By averaging the two tests together (Fig. 75) it appears that the 4-inch burlap, 3-ply, was the most effective, averaging for the two tests 258 larvae per band, the 8-inch paper-burlap, single thickness, a close second, averaging 253, and the same material, 4 inches wide, 2-ply, a close third with an average of 248. The three poorest were: 4-inch roofing paper, averaging 167; 4-inch crêpe paper, averaging 181; and 4-inch burlap, 2-ply, averaging 186 larvae per band.

Had the experiment been terminated at the end of the first test, or had only the second test been made, or had both series been combined in one test, only one interpretation would have been reached. From the two tests as made, however, the correct conclusion is not yet available, but certain facts are apparent.

HAUETER ORCHARD, 1928. The orchard used in 1928 was so badly infested that all of the fruit was wormy and unharvested. The trees were much larger than those used in 1927, and somewhat more uniform in size, but probably about as variable as to crop and other factors, and in addition consisted of several varieties. The rows of untreated bands were interspaced with rows of treated bands. The trunks were cleaned of most of the rough bark, and the bands applied July 10 and examined every 7 days until Sept. 11, after which 9 days intervened between each examination.

No new materials were tested in 1928.

In this test there was a much wider range in values between the better and the poorer materials than in the 1927 experiments. (Table 2.)

The best material (Fig. 76) was the 8-inch paper-burlap band, single thickness, averaging 1,322 larvae per band, while the second best was the same material 4 inches wide (except that the 4-inch material on both trunk and limbs caught more per tree). The least efficient was the crêpe paper which averaged only 336, and next to the poorest was the 6-inch 2-ply burlap, which averaged 472 larvae per band.

TABLE 2. NUMBER OF CODLING MOTH LARVAE CAPTURED UNDER UNTREATED BANDS. HAUETER ORCHARD. YAKIMA, WASH., 1928
(July 10–November 14)

Row No.	Kind of band	Number of trees	Total number of larvae	Average number of larvae per tree
1	Paper-burlap, 4-inch, single thickness	14	14,400	1,029
2	Paper-burlap, 8-inch, single thickness	13	17,181	1,322
5	Crepe paper, 4-inch, light colored, single thickness	13	4,374	336
6	Burlap, 4-inch, 3-ply	13	8,971	690
11	Paper-burlap, 4-inch, single thickness	14	12,934	924
14	Burlap, 6-inch, 2-ply	12	5,658	472
15	Paper-burlap, 4-inch, single thickness, on trunk and limbs	10	12,097	1,210
	Total	89	75,615	

Accurate orchard comparisons of banding materials can be made only under the following conditions: the trees must be uniform in size, in the character of the bark, in variety of fruit, in size of crop, and in degree of infestation. Obviously also the comparisons must run simultaneously, all bands must fit uniformly on all trees, and supplementary places

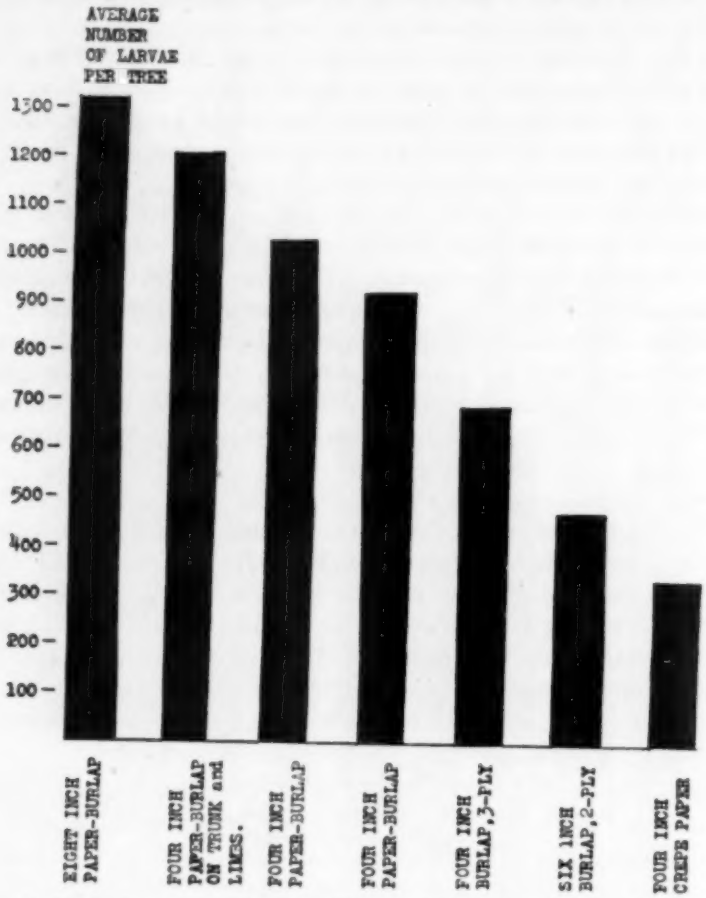

FIG. 76.—Average number of codling moth larvae caught in untreated bands, Haueter orchard, Yakima, Wash., 1928.

for pupation and hibernation must be uniformly equal. In no case that we can recall have all of these conditions prevailed. Large bands requisite for large trees cannot be compared with small bands on small trees; smooth-bark trees cannot be compared with rough-bark trees; especially susceptible varieties are not comparable with those much less

so; a crop of 1 bushel on a tree is not comparable with a crop of 30 bushels on another. A variation in the amount of light surrounding the banded trees has also been mentioned as a factor.[1] Owing to many variable factors the comparisons must be made simultaneously; loosely or poorly fitting bands are not comparable with snugly fitting ones; and bands on tree trunks surrounded with extraneous material suitable for pupation or hibernation purposes are not comparable with bands on trunks free of or differing in such supplementary quarters.

The tendency toward a rational average, for each item, in spite of any or all of the foregoing variables (except variety of fruit), is more or less increased as the number of trees in each test is increased or by replication or repetition of the tests. The more complete the elimination of all variables, the sooner comparable results are obtained. The more numerous or important the variables, the less accurate are the results, and the more repetition or replication is required to reach accurate deductions; this is especially true in cases where the items compared are not likely to show wide differences. In cases where there is a wide range between compared items, fairly accurate or approximate comparisons can be made more readily.

Most of the foregoing variables existed in these tests except that the comparisons were run simultaneously, the bark was cleaned rather uniformly, and there was but a single variety of fruit in the first two tests. However, by using a number of trees for each material, and by duplication and repetition of tests, some points of value are apparent.

Conclusions

Paper-burlap bands are as effective as the 3-ply burlap customarily used, and cost much less.[2]

Four-inch, single thickness paper-burlap bands were apparently not quite so efficient as single thickness 8-inch bands.

Folding the 8 inch paper-burlap bands to double thickness, with the open edge down, did not increase their effectiveness.

Four-inch paper-burlap was slightly more effective applied as a single thickness than when folded to 2-ply with the open edge down. The 2 inch band thus formed was apparently too narrow.

[1]Flint, W. P., and Goff, C. C., Banding for Codling Moth Control. In Journ. Econ. Ent. 22, p. 675–679, 1929.

[2]Paper-burlap is priced at 2⅔ cents per lineal yard in 8-inch widths; at 1⅓ cents in 4-inch widths. The 3-ply, 4-inch burlap costs 6 cents per lineal yard at Yakima, Wash.

Three-ply, 4 inch burlap proved more efficient than 2-ply whether 6 or 8 inches in width.

Crêpe paper, light colored, single thickness, 4 inches wide was next to the least effective in both tests in 1927, and the least effective in the 1928 test.

Four-inch paper burlap on both trunk and limbs was apparently somewhat more effective than on trunks alone.

THE RELATION OF THE HABITAT TO EUROPEAN CORN BORER POPULATIONS

By J. R. SAVAGE, *Ohio Agricultural Experiment Station*

ABSTRACT

Differences in habitats within the corn borer (*Pyrausta nubilalis* Hubn.) infested area are offered as a reasonable explanation of the differences in populations occurring in Ohio. Corn borer populations are correlated significantly with types of habitat.

It has been observed that the populations of European corn borer (*Pyrausta nubilalis* Hubn.) in Ohio fluctuate widely within the infested area. In a previous publication (1) it was pointed out that these variations were in large part accounted for in their relation to the habitat. It is the purpose of the present paper to lend additional support to these former observations.

As an introduction to the discussion which follows, the value of using the habitat as an index to favorable conditions will be considered. There are two independent groups of major factors, physical and biotic, which could be mainly responsible for such a variation. Physical factors may be divided into climate and soil. Climate may be eliminated at the outset, for altho the extremes of climate occurring in the infested area might be used to explain the differences in the populations in those extremes, climate cannot serve to explain the differences in the populations in adjacent fields. The soil and biotic factors are closely related and one or the other can be used with relative accuracy to account for the differences in the populations of adjacent fields, since where these factors are most favorable the greatest accumulations of corn borers will result. However, soil exercises only an indirect influence on corn borer populations thru its effect on the corn plant. The biotic factors offer the best indicator of population differences. The habitat forms an index for biotic factors and at the same time it is influenced by both climate and soil. It represents the resultant condition of the reactions and interrelations of all factors present.

During the season of 1928 data were taken in over 200 fields in the Bono area. Four types of habitat were characteristic of this region: swamp-forest (2), red-oak-transition, beech-maple, and muck. The majority of these fields embraced two or more of the habitats within their limits. However, among the entire number were found 34 in which the habitat was unmixed. In this lot of fields containing a single habitat all four types were represented. These fields were coded from 1 to 4 for their habitat type and the values arranged according to the corn producing ability of the habitat. From the poorest to the best in the production of corn they run as follows: (1) muck, (2) beech-maple, (3) red-oak-transition, and (4) swamp-forest. Correlating these coded habitats with their respective corn borer populations, the correlation coefficient is .48 with odds 1454 to 1 that the correlation is significant.

This correlation is relatively higher than it appears when some of the evaluable factors at work are considered. Date of planting, growth condition of corn, and height at peak of moth flight are some of the definite factors which affect corn borer populations (3). The planting date of these 34 fields, varied from May 7 to June 2. Some of the fields were tile drained, others were not. Some fields were fertilized. Still others were properly rotated and some had been in corn for years. The average height of the fields at the peak of moth flight varied from 39 to 52 inches. Any of the above factors may be more or less significantly correlated with corn borer populations. Since all of these factors have an effect on the degree of favorableness of a given habitat when subject to such variation, they cause a considerable deviation in the value of a given habitat from its true value and, therefore, lower the correlation coefficient.

The swamp-forest offers the most favorable conditions for corn borer accumulation. A correlation was made of the approximate percentage of the areas in swamp-forest[1] of 23 northern Ohio counties with their respective corn borer populations (4). This gave a correlation coefficient of .41 with odds of 55 to 1. Here again the correlation is not as high as might be expected, if favorableness of habitat is correlated with corn borer populations. Since the swamp-forest habitat does not cover an entire county and the corn borer population is not confined to the swamp-forest, an error is introduced into the calculation. This is aggravated by the fact that the corn borer has not been within the limits of all these counties for the same number of years and, therefore, the accumulations have been building up for unequal lengths of time.

[1]Transeau, E. N. and Sampson, H. C., unpublished reconnaissance survey of the forest types in Ohio made for the Department of Entomology, Ohio Agricultural Experiment Station, 1926–28

From the above it would follow that where the greatest percentage of swamp-forest occurred the greatest increase in corn borers should occur. This is the case. The correlation coefficient is .54 with odds of 20789 to 1 when a correlation is made between the percentage of swamp-forest in 23 northern Ohio counties and their respective increases or decreases in corn borer populations.

SUMMARY. The habitat offers a reasonable explanation of differences in corn borer populations within the infested area of Ohio. A relatively high correlation between types of habitats and corn borer populations occurs even when definite limiting factors are known to vary widely. In any of the 23 northern Ohio counties considered, the corn borer population is correlated significantly with the respective amount of swamp-forest within the county. The rate of increase in any one of these counties is significantly correlated with the percentage of swamp-forest occurring in it.

LITERATURE CITED

1. HUBER, L. L., NEISWANDER, C. R. and SALTER, R. M. 1928. The European Corn Borer and Its Environment. Ohio Agr. Exp. Sta. Bul. 429, pp. 169–178.
2. SAMPSON, H. C. 1927. The Primary Plant Associations of Ohio. Ohio Jour. Sci. Vol. 27, pp. 301–309.
3. NEISWANDER, C. R. and HUBER, L. L. 1929. Height and Silking as Factors Influencing European Corn Borer Population. Ann. Ent. Soc. Amer., Vol. 22, pp. 527–542.
4. U. S. D. A. 1929. European Corn Borer Infestation Survey. Michigan-Indiana-Ohio-Pennsylvania-(Western) New York, pp. 20–37.

CORRELATION OF CORN BORER POPULATION WITH DEGREE OF DAMAGE

By C. R. NEISWANDER and E. A. HERR,[1] *Ohio Agricultural Experiment Station*

ABSTRACT

Varying populations of the European corn borer, *Pyrausta nubilalis* Hubn., were established on different plots of each of three varieties of corn and the resulting effect on yield was ascertained. It was found that within the variety there was a direct correlation between borer population and reduction in yield, and that for the three varieties under observation there was an inverse correlation between per cent reduction in yield and length of season between planting and silking.

The question of degree of reduction in yield due to corn borer infestation is one that vitally concerns all persons interested in corn production. It is of economic interest to corn growers who wish to know how to measure losses caused by the insect, since such information is

[1]The writers desire to acknowledge the assistance of Dr. L. L. Huber who has contributed greatly to the analysis of the data.

necessary before they can decide to what extent they can spend effort and money in an attempt to prevent these losses. And the question is of particular importance to investigators attempting to develop control measures since upon it rests the proper interpretation and evaluation of their results.

From casual observation in the field it is practically impossible to arrive at even a fairly accurate approximation of the damage being done because of the nature of the injury caused by the insect. If the corn borer would attack one field and leave uninjured a neighboring field of a similar variety, equal quality and the same development rate the two might be compared, but such a condition has never been found to exist. On the contrary such fields are very likely to have approximately equal infestations. Because of the extreme variations in yield that occur as a result of differences in soils, planting dates, varieties, rotations and other farm practices it is extremely difficult to establish fair expectation levels from which to make comparisons. For this reason no accurate measure of damage done by the corn borer can be made by correlating population with yield in neighboring fields.

If an attempt is made to compare yields from infested plants with those from non-infested plants where both have been equally exposed to attack the data are of but little, if any, value. It has been shown that the larger and better plants within an area are more susceptible to infestation. Hence the infested stalks by reason of their greater vigor may be able not only to carry their borer load but actually may outyield the weaker uninfested ones, a condition which actually has been found to exist in some early investigations.

A decrease in production as a result of the presence of borers in dent corn is not distinctly observable by superficial examination until a population of three or four borers per stalk has been reached and the actual reduction in yield is usually not regarded as severe until a borer population of six or eight borers per stalk has occurred. The variations in damage due to fluctuations in population should be measurable, however, even with variations in population no greater than one borer per stalk, provided separation of the different populations can be made and environmental conditions kept uniform.

Probably the first and most prominent indication that borer damage is being done in a corn field is the breaking of the tassels and infested stalks. While stalk breakage is not a specific measure of the reduction in yield resulting from the presence of corn borers it is nevertheless a distinct indication of corn borer injury. The amount of breakage that occurs within a field having a given population will depend, of course,

upon the weather conditions, degree of maturity, and the type of corn grown. However, the average breakage that occurs over a number of different varieties, each having a range of populations and all being subjected to the same weather conditions should be proportional to the borer population.

In Table 1 is given the percent of stalks broken and the percent detasseled for various populations under observation in 1927. The populations considered were the averages obtained from six varieties observed for the three main planting dates of the year. In obtaining this record a total of 510 stalks were observed for each population. In columns three and five the average amount of stalk breakage and detasseling per borer that occurred are computed respectively for the different population levels.

TABLE 1. SHOWING BORER POPULATION CORRELATED WITH PERCENT STALK BREAKAGE AND DETASSELING

Population per stalk	Percent broken		Percent detassled	
	Actual	Av. per borer	Actual	Av. per borer
3.27	22.1	6.8	56.9	17.3
2.04	18.2	8.9	50.3	24.7
1.31	9.5	7.3	28.9	22.1

Bul. 429 Ohio Agr. Exp. Sta. p. 129.

It may be seen that as the population increases there is a coincident increase in both percent broken and percent detasseled stalks, the coefficient of correlation between stalk breakage and population being .85. The odds calculated from the formula $t = \frac{r}{\sqrt{1-r^2}} \times \sqrt{n'-2}$ as given by Fisher are over 9,999 to 1 that the correlation is significant. The regression of percent of stalk breakage on population is 6.09. That is, considering all varieties for the three population levels shown in the table, the stalk breakage increased 6.09 percent for each borer per stalk increase in population.

During the season of 1928 a definite effort was made to ascertain the relationship existing between reduction in yield and increase in borer population. Accordingly, five plots ten hills square were selected for study in a uniformly growing field of early planted corn. These plots were examined for eggs every second day throughout the egg deposition season, the location of the egg masses being recorded by hills on a chart for each plot.

In order to produce the desired variation in population on the different plots all eggs were removed from plot one and their equivalent placed on plot five; half of the eggs were removed from plot two and their

equivalent placed on plot four; while plot three was left undisturbed except that a complete record was made of all eggs deposited. In this way there was established among the plots a ratio in egg deposition of 0, 1, 2, 3, 4. The final egg deposition record for all plots was as given in Table 2.

TABLE 2. SHOWING EGG RECORD ON DAMAGE PLOTS (BONO—1928)

Plot No.	Egg masses	Eggs per plant	Ratio
1	6	.4	1
2	149	9.5	25
3	320	19.9	54
4	472	27.9	79
5	626	35.8	104

In taking the final record the individual ear weight was noted for each stalk of the different plots and the borer population for the respective stalks was obtained. In this way the population and damage could be correlated for the different plots. In like manner the ear weights for individual stalks could be correlated with the respective borer populations for those stalks regardless of the plots in which they occurred. The final plot record of population and damage is shown in Table 3.

TABLE 3. SHOWING CORRELATION OF BORER POPULATION WITH YIELD—BONO—1928

Plot No.	No. of plants	Total No. borers	Borers per stalk	Yield in bu. per acre
1	159	270	1.69	73.55
2	157	439	2.79	71.85
3	158	581	3.67	69.23
4	172	870	5.05	58.90
5	177	1111	6.27	67.26

The data presented in Table 3 tend to indicate that the yield is reduced progressively as the borer content per stalk is increased. The coefficient of correlation between borer population and yield is — .7496, but the odds are only 12 to 1 that this correlation is not due to chance.

Soil differences, growth records, silking dates, and farm practices were all observed for the different plots in order to note if any factor other than population might be responsible for the differences in yield obtained. In only one respect was there found to be a difference that might be thought to cause a variation in yield. Plots one to four were cultivated at silking time while plot five was not. Since the cultivation was rather deep it is possible that the yield on the cultivated plots was materially reduced and that plot five, therefore, had a proportionately higher yield than its population would warrant. It is also possible that the increase in yield in plot five may have been due to some other unknown factor.

During the season of 1929 a more complete damage project was planned and executed. Six levels of population were established on

each of two field corn varieties, Smoky Dent and Burr Leaming, and three replications were made for each level. In addition one sweet corn variety, Golden Bantam, was grown with three levels of population and two replications for each level.

The plots of all varieties and all replications were six hills square with one infested border row entirely around the plot to secure an even distribution of population throughout, and with two uninfested border rows surrounding the infested plot to take up the migrating larvae. The infestations in all population levels for each variety were initiated at the same time in order that the developing larvae might all be subjected to the same general environmental conditions.

The field in which the experiment was conducted was fairly uniform in topography, soil type and texture. However, due to unfavorable moisture conditions during the forepart of the season a somewhat uneven stand resulted. There was not sufficient moisture present to produce uniform germination. This condition undoubtedly affected the yield as well as the percent of survival, but since the irregularity was common to all plots of the experiment it should have little, if any, bearing upon the results obtained.

In obtaining the final record, individual ear weight was taken for each stalk of the different plots and the borer population for the particular stalk was noted as in the preceding year's work. In case of the sweet corn the reduction in yield was computed in the same manner as in the field corn except that the yield was taken during the roasting ear stage. The yield is thus based on the actual weight of roasting ears instead of on the15.5 percent moisture basis used for field corn.

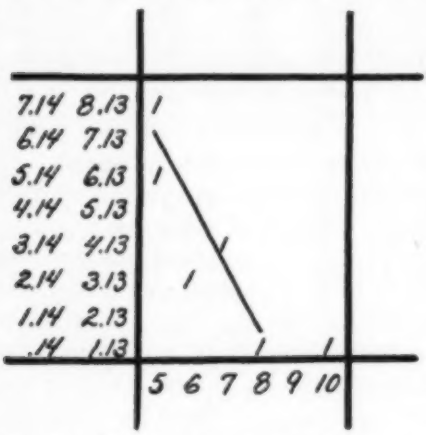

Fig. 77.—Showing Correlation of Population per stalk and Yield per stalk in Golden Bantam Sweet Corn.

The correlation between borer population and yield in Golden Bantam is —.7974 (Figure 77), the odds being 45.7 to 1 that there is a significant correlation. For each borer increase in population in this variety there was a reduction in yield of 5.4 percent as figured from the regression equation of population on yield using this correlation coefficient.

In the two field corn varieties, the population and yield records were both taken in the fall after the corn was mature. Moisture samples were taken for each plot and the yield figured on a 15.5 percent moisture basis.[2] The averages of the replications for each population level in Smoky Dent are given in Table 4.

TABLE 4. CORRELATION OF BORER POPULATION WITH YIELD IN SMOKY DENT VARIETY, OAK HARBOR—1929

Pop. level	Pop. per 100 stalks	Yield in bu. per acre
1	22	57.9
2	139	54.2
3	249	50.3
4	457	48.9
5	634	47.0
6	690	40.6

By reference to Table 4 it may be seen that as the population increases there is a steady decrease in yield, the highest population level obtained being 690 borers per 100 stalks where a reduction in yield of 17.3 bushels or 30 percent of the crop was obtained when compared with the first level alone as a check.

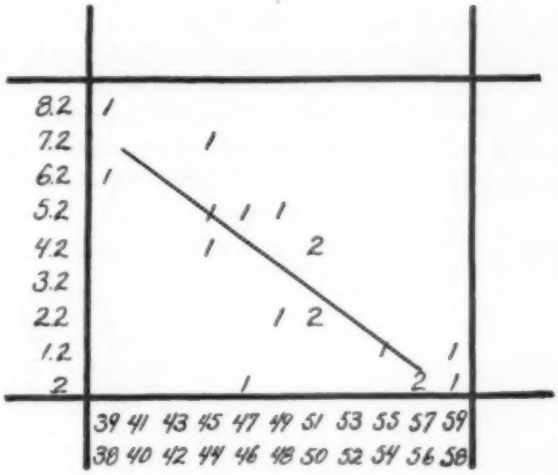

Fig. 78.—Correlation Table for Population versus Yield in Smoky Dent Field Corn.

The coefficient of correlation between borer population and yield in the Smoky Dent variety is —.8230 (Fig. 78) with odds of 9,999 to 1 that this correlation is significant. For each borer increase in population there was a reduction in yield of 3.25 percent.

[2]Moisture determinations were made by the Department of Agronomy.

In the Burr Leaming variety, due to lower establishment rates, the populations obtained in the different levels were lower than in Smoky Dent although the same number of eggs was used in the corresponding levels of the two varieties. The population per one hundred stalks and the yield in bushels per acre for the different levels are given in Table 5.

TABLE 5. CORRELATION OF BORER POPULATION WITH YIELD IN BURR LEAMING VARIETY

Pop. level	Pop. per 100 stalks	Yield in bu. per acre
1	10	59.1
2	57	54.3
3	120	52.3
4	176	53.1
5	276	49.7
6	356	50.0

The coefficient of correlation between borer population and yield in Burr Leaming is — .5875 with odds of 199 to 1 that this correlation is significant. For each additional borer increase in population there was a reduction in yield of 1.8 percent.

All of the damage records discussed in this paper occurred with populations under ten borers per stalk and for that reason do not necessarily apply to high populations. Nevertheless they should be comparable with each other. In Table 6 the silking dates, length of season between planting and silking and the percent reduction in yield for each borer increase in population are given for each variety used in the 1929 tests.

TABLE 6. SHOWING PERCENT DAMAGE PER BORER FOR THREE VARIETIES OF CORN, 1929

Variety	Average silking date	Days from planting to silking	Reduction in yield per borer
Golden Bantam	Aug. 9.4	73.4	5.4%
Smoky Dent	Aug. 13.5	77.5	3.25%
Burr Leaming	Aug. 20.2	84.2	1.8%

The foregoing data (Table 6) indicate that there is considerable variation in the damage resulting to different varieties from a given borer population, the amount of damage per borer increasing as the length of growing season of the variety decreases. Since, in general, the length of growing season of a variety is directly proportional to the size of the stalk the explanation of the above variation probably lies in the fact that in a variety like Golden Bantam the percentage of food and water conducting tissue that has been cut off by the borer tunnel is much higher than in a large stalk variety like Burr Leaming. Conse-

quently the influence of each borer of population on the percentage of transportation of food material is correspondingly less as the size of plant increases and as a result, the smaller stalk varieties suffer greater damage.

CONCLUSION. In planning this project it was hoped that by ascertaining the ratio existing between borer population and reduction in yield, the damage occurring within any field could be readily computed after determining the borer population. However, the results of the investigations reported here indicate that there is not likely to be established a specific formula, based upon borer population per stalk alone, for measuring damage that will apply to all varieties, soils, planting dates, seeding rates, crop rotations and weather conditions. The writers believe that the same populations established on the varieties presented here would not produce identical results another year because of the above mentioned factors. Nevertheless the amount of damage per average borer of population can be correlated in a general way with the nature of the variety according to the scale given in Table 6.

THE EFFECT OF TEMPERATURE, RELATIVE HUMIDITY AND EXPOSURE TO SUNLIGHT UPON THE MEXICAN BEAN BEETLE

By D. F. MILLER,[1] *Field Assistant, Truck-Crop Insect Investigations, Bureau of Entomology*

ABSTRACT

This series of laboratory experiments and field tests indicates that there is a specific relation between relative humidities and temperatures in the survival of the Mexican bean beetle (*Epilachna corrupta*) at high summer temperatures.

Experimental studies like those of Shelford (*9*)[2] and Headlee (*4*), and some more recent work like that of Chapman (*2*), Beattie (*1*), and Hefley (*5*) have indicated that atmospheric humidity and evaporation rate are very important factors in the life histories and ecology of insects. To some extent this also seemed to be true for the Mexican bean beetle, according to field data collected by Howard[3] and Douglass (*3*). It

[1]Assistant Professor, Department of Zoology and Entomology, Ohio State University. This work was performed during the summers of 1928 and 1929, while the writer was employed as Field Assistant on the bean-insects project of the Bureau of Entomology, U. S. D. A.

[2]References made by number in italics refer to literature cited at end of paper.

[3]Howard, Neale F. Studies on the atmospheric evaporation in relation to bean beetle abundance. Unpublished notes.

seemed advisable, therefore, to make a rather careful study of this problem under completely controlled conditions in order to determine with some exactness how important were the effects of these factors upon the bean beetle.

APPARATUS. A single unit of the apparatus that was constructed to control and measure the humidity and evaporation rates is shown in Figure 79. Six units were used in order to make possible the running of a variety of humidities simultaneously. The materials used were sulphuric acid, saturated solutions of sodium hydroxide, sodium bromide, sodium chloride, sodium nitrate, and distilled water; and the percentages of relative humidity obtained by their use were approximately 0, 30, 56, 73, 80, and 100.

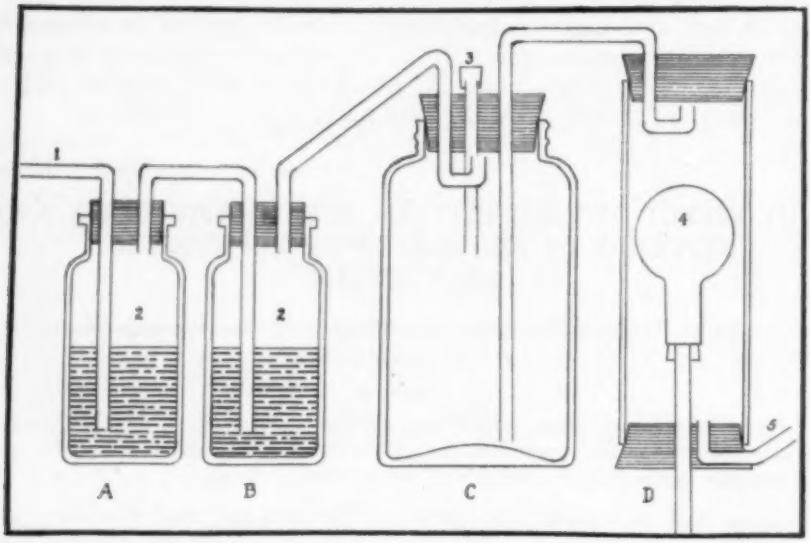

Fig. 79.—A and B, Bottles containing solutions to produce known relative humidities. C, Experimental chamber where beetles were placed during the experiment. D, Glass cylinder containing atmometer over which air was drawn in order to get the relative rates of evaporation. 1, Glass tube furnishing the inlet for the air current. 2, Salt solution or acid through which air was drawn to give it a known relative humidity. 3, Tube through which a thermometer was thrust to obtain the temperature of the inside of the experimental chamber. 4, Atmometer for recording the rate of evaporation. 5, Outlet tube connected with the pump on the water tap.

Parts A and B, bottles containing solutions producing known vapor tensions, and part C, a honey jar used as an experimental chamber, are similar in principle to apparatus used previously by Headlee and by

Hefley. Part D is a glass cylinder closed at both ends by rubber stoppers. The standard porous cup atmometer was placed inside the cylinder and the air from the experimental chamber C entered the upper end of the tube and passed down around the atmometer cup and out through the outlet, 5, to a suction pump attached to a water tap. Separation of the atmometer from the experimental chamber insured the correct percentage of humidity in the chamber.

Relative Evaporation Rates at Normal Temperatures. Of all the parts of the life history it was decided that those most susceptible to the effects of evaporation and humidity would be: (1) incubation, (2) larval period, (3) ecdysis, (4) pupation period, and (5) emergence. The first of these was postponed because of certain difficulties involved, but the others were tried, since mature larvae could be started, ecdysis would occur at time of pupation, the pupae would remain quiescent during the pupal period, and emerge as adults, all without feeding.

Mature larvae which had stopped feeding and most of which had already attached themselves preparatory to pupation were put into small screen-wire cages and placed in the experimental chambers (Figure 79, C). They were left here until they had passed through the pupal period and emerged as adults. They were examined daily during this period and records made of their condition.

Temperatures in the experimental chambers were checked three times per day and averaged. The greatest variation in temperature for any one day was from 25.8° to 31.1° C.; and for the entire period, from 22.1° to 31.1° C. The results of running the experiment for thirteen days are summarized in Table 1.

Table 1. Summary of the Effects of Relative Humidity and Rate of Evaporation on the Later Stages of the Mexican Bean Beetle

Per cent of relative humidity	Evaporation (cc.) Daily	Total	Number of larvae started	Number of larvae pupating	Number of adults emerging	Per cent of survival
0	25.14	264.0	31	31	31	100
30.7	17.83	187.2	31	31	30	96.6
56.18	8.2	94.3	31	30	29	93.3
73.4	6.60	69.7	31	30	30*	100
80.03	5.70	65.6	31	30*	30	100
100.0	1.06	12.3	31	30	30	96.6

*One individual killed in handling.

These figures show that for the extremes of dry and saturated air the percentages of pupation and emergence were very high and at no degree of relative humidity did the survival fall below 93 per cent, a figure well above normal for field conditions.

TABLE 2. SURVIVAL OF ADULTS OF THE MEXICAN BEAN BEETLE EXPOSED FOR THREE HOURS TO HIGH TEMPERATURES AND DIFFERENT RELATIVE HUMIDITIES

Per cent of relative humidity	Temperature °C.	Number of beetles used	Number of beetles killed	Number of survivals	Per cent of survivals
0.0	37.5	100	3	97	97.0
30.72	37.5	100	1	99	99.0
56.18	37.5	100	2	98	98.0
73.414	37.5	100	3	97	97.0
80.035	37.5	100	7	93	93.0
100.0	37.5	100	2	98	98.0
Check	26.0	100	2	98	98.0
0.0	38.5	260	128	132	50.8
30.72	38.5	260	105	155	59.6
56.18	38.5	260	97	163	62.7
73.414	38.5	260	51	209	80.4
80.035	38.55	260	118	142	54.6
100.0	38.5	260	180	80	30.8
Check	26.6	260	17	243	93.5
0.0	39.5	260	166	94	36.2
30.72	39.5	260	166	94	36.2
56.18	39.5	260	158	102	39.2
73.414	39.5	260	87	173	66.5
80.035	39.5	260	163	97	37.3
100.0	39.5	360	235	25	9.6
Check	27.3	260	1	259	99.6
0.0	40.5	100	92	8	8.0
30.72	40.5	100	92	8	8.0
56.18	40.5	100	84	16	16.0
73.414	40.5	100	66	34	34.0
80.035	40.5	100	99	1	1.0
100.0	40.5	100	100	0	0.0
Check	25.0	100	0	100	100.0
0.0	41.5	100	98	2	2.0
30.72	41.5	100	97	3	3.0
56.18	41.5	100	91	9	9.0
73.414	41.5	100	81	19	19.0
80.035	41.5	100	99	1	1.0
100.0	41.5	100	100	0	0.0
Check	25.5	100	2	98	98.0
At all humidities	42.5	100	100	0	0.0
Check	26.0	100	5	95	95.0

Table 1 shows clearly that for normal summer temperatures with no sudden or great variations, for relative atmospheric humidities varying from approximately 0 per cent to approximately 100 per cent, and for relative evaporation rates varying from 1.06 cc. to 25.14 cc. per day the Mexican bean beetle is sufficiently resistant to pass through its final ecdysis, pupation, and emergence with no apparent effect from the abnormal conditions.

RELATION OF RELATIVE HUMIDITY TO TEMPERATURE. The failure of the experiment of relative humidity and evaporation rate at ordinary

summer temperatures to disclose any effect upon the beetles from the late larval stage to adult, led to the idea of testing relative humidity with higher temperatures. Some previous work with temperature by Kramer (*6*), Miller and Gans (*7*), Miller (*8*), and especially Beattie (*1*) and Hefley (*5*) showed that temperature is a vital and perhaps the most important single factor in insect life and activity.

Apparatus: Parts of the apparatus used in the preceding experiment (Figure 79, A, B, C,) were installed in a large electrical oven for the regulation of temperatures.

TABLE 3. SURVIVAL OF LARVAE AND PUPAE OF THE MEXICAN BEAN BEETLE EXPOSED FOR THREE HOURS TO HIGH TEMPERATURES AND DIFFERENT RELATIVE HUMIDITIES

Per cent of relative humidity	Temperature °C.	Number of larvae used	Per cent of survival	Number of pupae used	Per cent of survivals
0.0	37.5	100	96	100	99
30.72	37.5	100	100	100	97
56.18	37.5	100	99	100	100
73.414	37.5	100	100	100	99
100.0	37.5	100	97	100	98
Check	—	100	94	100	97
0.0	38.5	100	88	100	83
30.72	38.5	100	91	100	94
56.18	38.5	100	93	100	93
73.414	38.5	100	96	100	95
100.0	38.5	100	94	100	79
Check	—	100	97	100	95
0.0	39.5	200	88	100	86
30.72	39.5	200	88	100	89
56.18	39.5	200	82.5	100	85
73.414	39.5	200	89	100	94
100.0	39.5	200	88	100	90
Check	—	200	98	100	92
0.0	40.5	110	60	120	30
30.72	40.5	110	68.1	120	33.2
56.18	40.5	110	77.2	120	35
73.414	40.5	110	91	120	46.6
100.0	40.5	110	82.7	120	40
Check	—	110	97.2	120	92.5
0.0	41.5	130	2.3	100	6
30.72	41.5	130	10.7	100	0
56.18	41.5	130	0.0	100	1
73.414	41.5	130	10.7	100	3
100.0	41.5	130	3.1	100	4
Check	—	167	86.8	100	89
0.0	42.5	100	3	100	0
30.72	42.5	100	4	100	0
56.18	42.5	100	3	100	0
73.414	42.5	100	1	100	0
100.0	42.5	100	0	100	0
Check	—	100	98	100	93

Methods and results: When the oven had reached a given constant emperature the beetles were counted out and placed in the experimental

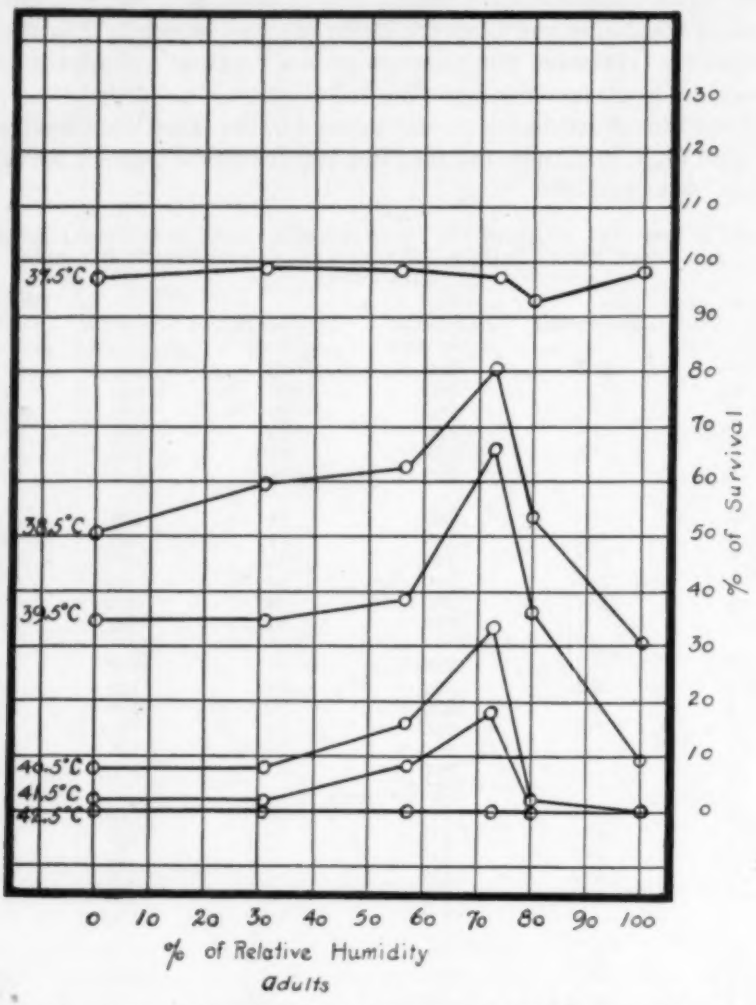

Fig. 80.—Chart showing the effects of exposure to various temperatures at different relative humidities upon the survival of adults of the Mexican bean beetle. (The percentages of survival in the checks were 98, 93.5, 99.6, 100, 98, and 95; see Table 2.)

chambers of the apparatus (Figure 79, C), an equal number in each chamber, and exposed to the temperature for three hours. After the exposure they were removed and allowed to stand from fourteen to sixteen

hours, and then the beetles were removed and carefully examined to determine the percentage which had survived. For comparison, in each

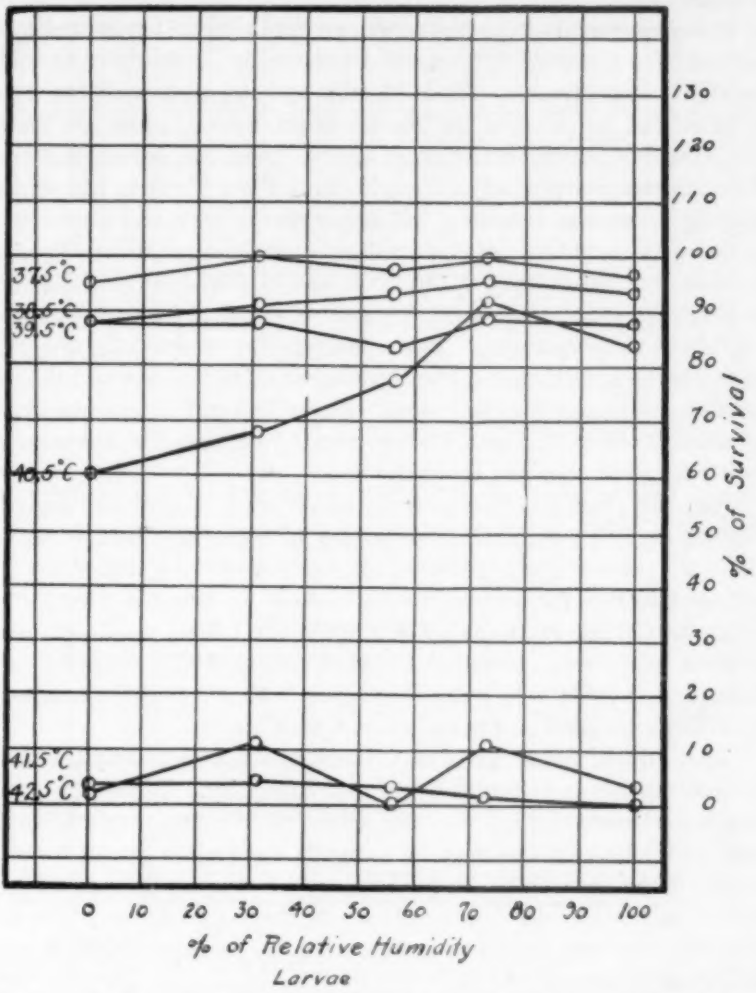

Fig. 81.—Chart showing the effects of exposure to various temperatures at different relative humidities upon the survival of larvae of the Mexican bean beetle (The percentages of survival in the checkswere 94, 97, 98, 97.2, 86.8, and 98; see Table 3.)

experiment, a check chamber was run outside the oven at room temperature. The very definite results obtained are summarized in Tables 2 and 3.

On the graphs of Figures 80, 81, and 82 the temperatures used (37.5,° 38.5,° 39.5,° 40.5,° 41.5,° 42.5° C.) are shown along the left margin; each per cent of relative humidity (given in Tables 2 and 3) and each per cent of survival of the larvae, pupae, and adults is indicated by the position of a circle with reference to the scale at the bottom and at the right, respectively. These should be compared with the results of the checks (as given in the legends of the figures) to obtain the true kill. It will be noticed here that at 37.5° C. there was normal survival at all humidities giving nearly a straight line. For a 1° rise in temperature, however, there was a marked kill below 60 per cent and above 80 per cent relative humidity, with a very decided optimum at about 73 per cent. For temperatures of 39.5° C., 40.5° C., and 41.5° C., the results are very similar, with a decidedly lower per cent of survival for each increase of one degree of temperature. For a temperature of 42.5° C., one degree higher, there was an almost complete kill at all humidities and the curve becomes essentially a straight line. Regardless of the temperature, the optimum humidity is near 73 per cent. These results are somewhat similar to those obtained by Hefley (*5*).

From the graphs it is apparent that there is a critical thermal increment at about 40.5° C. Below this temperature there is no great gap in the percentages of survival for each rise of 1° C., and above it the same holds true, but from 39.5° C. to 41.5° C. there is a wide break.

Egg hatch: All attempts to determine the effects upon per cent of hatch in eggs showed tendencies toward results similar to that for other stages, but the mortality was so high even in checks that the results were not considered valid and hence are not presented.

The results of this series of experiments show very clearly the definite relationship between temperature and humidity. While the temperatures used were all high they are within the range of an occasional hot spell for climate such as may be found in the United States from Ohio south. They are well below the temperature frequently reached at the surface of the ground where exposed to the summer sun. The three-hour exposure was chosen as representing the probable duration of high temperature for any one day.

The fact that from 37.5° C. down there was no effect of either temperature or humidity explains why the first experiment on relative humidity and rate of evaporation gave completely negative results.

Field Tests. Exposure to sunlight: In order to check in the field some of the results obtained by the preceding laboratory tests, pupae were exposed to bright direct sunlight. The leaves containing pupae were turned over and tied to stakes so as to expose the pupae to the direct

rays of the sun. Different lengths of time were taken for the exposure and days were chosen when comparative temperatures varied consider-

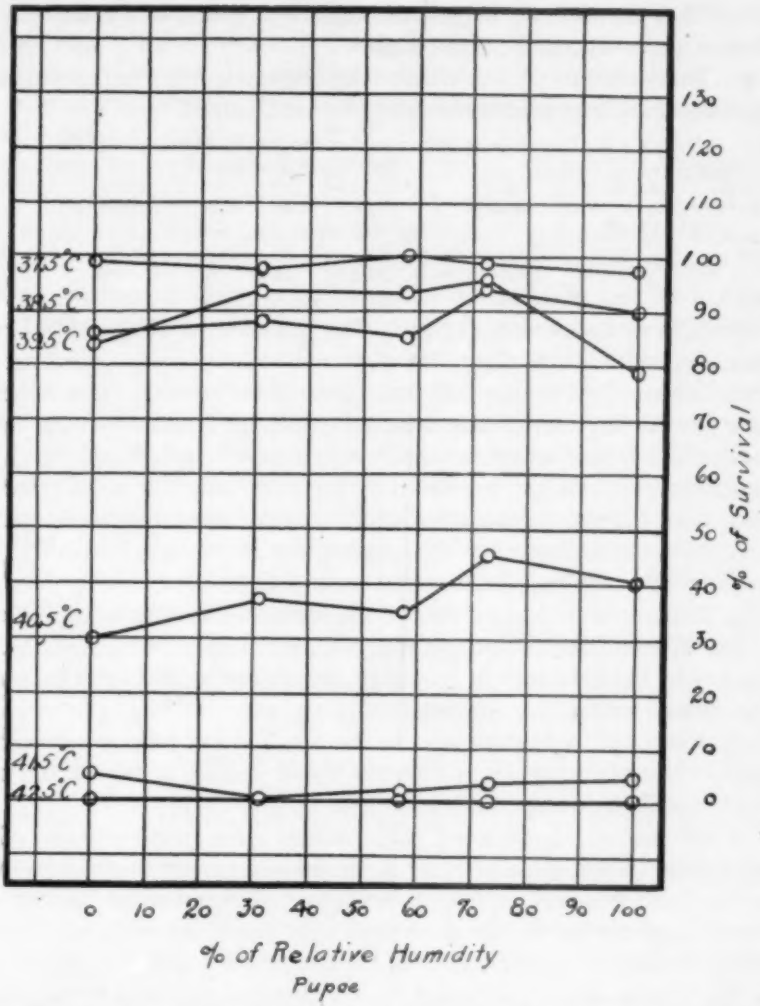

Fig. 82.—Chart showing the effects of exposure to various temperatures at different degrees of humidity upon the survival of pupae of the Mexican bean beetle. (The percentages of survival in the checks were 97, 95, 92, 92.5, 89, and 93; see Table 3.)

ably so as to make it possible to test for the effects of temperature and light rays separately. The results, which are summarized in Table 4, show:

a. That exposure for short periods (3 hours), when the temperature is high, kills pupae, since only 32 per cent of the exposed pupae emerged while 91 per cent of a check emerged.

b. That exposure for longer periods (15–18 hours) has practically no effect if the temperature is not high.

c. That it seems probable that temperature is more important than light rays in killing when exposure occurs in the field.

TABLE 4. EFFECTS OF EXPOSURE OF PUPAE TO MID-DAY SUN

Number of pupae	Length of exposure Hours	Hours of day	Mean temperature °C.	Number alive	Number died	Percentage of survival Experiment	Check
64	3	12.00–3.00	35	20	44	32	91
64	15	9.00–12.00	26.5	56	8	88	98
106	18	11.30–7.30	24.5	102	4	96.2	88

Position of beetles on the leaf: The question of the orientation of insects upon their host plants is a matter of both biological and economic importance. This is especially true in artificial control. The Mexican bean beetle, like many other insects, is usually found upon the under surface of the leaf where it feeds, ordinarily not breaking through the upper surface. Various explanations for this limitation of its activities have been suggested, usually with very little supporting evidence.

a. Response to gravity. Since the question is one of position, geotropism naturally suggests itself as an explanation.

b. Differences in leaf surface. This involves a number of things, such as the different nature of the surfaces themselves, the clinging ability of the beetle, the difference in humidity, the ability of the beetle to feed on one surface rather than the other, etc.

c. Response to light or heat of the sun. It has been observed that many more beetles are found on the upper surface of leaves just after daybreak than during later hours of the day.

A few specific tests were made which gave considerable definite information upon these points. A potted bean plant was suspended in an inverted position in bright sunlight. A number of beetles were placed upon the leaves in a place exposed to the direct sunlight. In most cases this was the under surface of the leaf which was now turned uppermost. The beetles immediately showed signs of restlessness and moved about until they came to the shaded side of a leaf. This was usually the upper surface which, being inverted, was not now exposed to direct light. If the leaf was turned edgewise with neither surface above or below, the beetle "chose" the shaded side regardless of which one it was. The response was negative to either the light or temperature which was about 34° C. in the sun on this day. The beetles had been taken from cages where food was not plentiful. Feeding commenced almost at once and

those beetles which came to rest upon the upper leaf surface began feeding upon it as readily as those on the lower surface.

To check these rather obvious results, a screen was placed in such a position as to shade the plant from direct sunlight. Then a mirror was set beneath the plant and the light of the sun reflected up against the leaves. This placed most of the beetles in the bright light again, whereupon they showed signs of restlessness and moved to less lighted areas as before.

This experiment was repeated later at a time when the temperature was not above 28° C. and the same results were apparent.

It would seem from the above that the distribution of the Mexican bean beetle upon the plant was primarily influenced by the intensity of the light rather than by gravity, leaf surface, ability to feed, or temperature, although they may respond to these influences when light does not enter in.

To test this, larvae were placed on plants which were then kept in a dark room. Counts made over a period of several days gave a total of 125 larvae on the under surface of leaves as compared with 84 on upper surfaces, stems, and cage walls. Other experiments carried on at the same time in a dark room by Howard and Mason in connection with a different project showed very similar distribution in the dark. Feeding had taken place on all parts of the plants, which seems to indicate that the only factor of much importance is light.

Literature Cited

1. Beattie, Mary V. F. (1928). Observations on the thermal death points of the blow-fly at different relative humidities. Bull. Ent. Research, 18 (4): 397–403, illus.
2. Chapman, R. N. (1928). The quantitative analysis of environmental factors. Ecology, 9 (2): 111–122, illus.
3. Douglass, J. R. (1928). Precipitation as a factor in the emergence of Epilachna corrupta from hibernation. Jour. Econ. Ent. 21: 203–213, illus.
4. Headlee, T. J. (1917). Some facts relative to the influence of atmospheric humidity on insect metabolism. Jour. Econ. Ent. 10: 31–38.
5. Hefley, H. M. (1928). Differential effects of constant humidities on Protoparce quinquemaculatus Haworth, and its parasite, Winthemia quadripustulata Fabricius. Jour. Econ. Ent. 21: 213–221, illus.
6. Kramer, S. D. (1915). The effect of temperature on the life cycle of Musca domestica and Culex pipiens. Science, n. s. 41: 874–877.
7. Miller, D. F., and Gans, M. (1925). Some observations on the reactions of the ant Cremastogaster lineolata (Say) to heat. Jour. Comp. Psych. 5 (6): 465–473.
8. Miller, D. F. (1929). Determining the effects of change in temperature upon the locomotor movements of fly larvae. Jour. Exp. Zool., 52 (2): 293–313, illus.
9. Shelford, V. E. (1913). The reactions of certain animals to gradients of evaporating power of air. A study in experimental ecology. Biol. Bull. 25: 79–120, illus.

A QUALITATIVE ANALYSIS OF THE DIGESTIVE SECRETIONS OF THE LARVA OF THE JAPANESE BEETLE (*POPILLIA JAPONICA* NEWM.)[1]

By MILLARD C. SWINGLE, *Assistant Entomologist, Bureau of Entomology, United States Department of Agriculture*

ABSTRACT

An analysis of the secretions of the digestive tract of larvae has shown the presence of the basic ions of aluminum, ferrous iron, calcium, magnesium, potassium, sodium, and ammonium. The acidic ions found present were carbonate, chloride, nitrite, and phosphate.

The inorganic ions are, from the standpoint of economic entomology, among the more important constituents of insect digestive secretions. They directly influence the reactions taking place within the digestive tract, particularly between the digestive secretions and foreign compounds introduced as stomach poisons. In this connection a study of the various ions present is of considerable importance to the economic entomologist.

The following paper is a qualitative study of the inorganic ions present in the digestive secretions of the larva of the Japanese beetle, *Popillia japonica* Newm. In order to test for those ions normally present, and to eliminate those which are incorporated in the food, overwintering larvae were first fed on high-grade filter paper for a period of four days to insure complete displacement of the soil within the digestive tract. The larvae were then dissected and the contents of the entire digestive tract removed and analyzed for any inorganic constituents.

METHOD AND RESULTS. The larvae used in this work were selected from a lot dug between January and March, special attention being given to selecting only the healthiest specimens. Three hundred of these larvae were brought into the laboratory where the average temperature was about 75° F. and were held in a box of soil until used. A large quantity of high-grade, practically ashless filter paper was crumpled up in the hand and moistened with distilled water. This moist paper was placed in one-ounce, seamless, tin salve boxes to each of which was added a single larva. The tins were then placed in a constant temperature chamber and held for four days at a temperature of 80° F., at which time the larvae had fed on the filter paper and had displaced all the soil within their digestive tracts.

After displacement of the soil within the digestive tract by filter paper, the larvae were opened by cutting along the mid-dorsal line

[1]Contribution No. 81. Research Laboratories, Moorestown, New Jersey.

from the posterior forward, and pinning out in a paraffin dissecting dish. The body cavity and digestive tract were then washed with several changes of distilled water from a pipette. This water was then removed and the contents of the entire digestive tract withdrawn with a pipette having a moderately fine point.

The material from 200 larvae was removed and placed upon a round filter paper in a round dish such as a bacteriological culture dish. This dish was kept under a warm desk light to permit the evaporation of all liquids from the paper. When thoroughly dried in this manner and the lid of the dish replaced, the material can be kept indefinitely. When ready for analysis the filter was folded, placed in a glass funnel over a 200 cc. flask, and 100 cc. of hot distilled water, slightly acidified with nitric acid, was poured repeatedly through the paper. This solution was then stoppered and labeled "Solution A" for the determination of basic constituents.

The material from another hundred larvae was collected in a 100 cc. flask and made up to 50 cc. with distilled water. The flask was then stoppered and labeled "Solution B" for the determination of ammonium and acidic constituents.

ANALYSIS OF SOLUTION A. The solution was first evaporated in a casserole and heated with concentrated sulfuric and nitric acids to destroy the organic matter (*1*).[2] It was then evaporated to dryness and 16 cc. of 6 N. sulfuric acid and 20 cc. of water added to dissolve the residue. The solution was then divided into 18 cc. portions which were placed in separate 50 cc. flasks and analyzed.

The first portion of solution A was analyzed by the procedure outlined by Noyes (*1*) for the analysis of basic constituents. The basic ions found in the solution were aluminum, iron, calcium, magnesium, potassium, and sodium. Other ions tested for but not demonstrated were silver, mercury, lead, bismuth, copper, cadmium, arsenic, antimony, tin, chromium, manganese, zinc, cobalt, nickel, barium, and strontium. In the course of this procedure the phosphate ion was detected.

The second portion of solution A was analyzed by the procedure given by Scott (*2*). The results were identical with those given above.

ANALYSIS OF SOLUTION B. This solution was analyzed by the procedure given by Noyes (*1*). The basic constituent, ammonium, was detected in 5 cc. of this solution. Two cc. of the solution were analyzed to determine the state of oxidation of the iron, which was found to be ferrous. The remainder was analyzed for acidic constituents. Those found were carbonate, chloride, and nitrite. Those tested for but not demonstrated were sulfate, sulfite, chromate, fluoride, oxalate, sulfide,

[2]Reference is made by number (italic) to Literature Cited, below.

cyanide, ferro- and ferricyanide, chlorate, hypochlorite, iodide, thiocyanate, bromide, and nitrate.

SUMMARY. A qualitative chemical analysis of the digestive secretions of the larva of the Japanese beetle has shown the presence of the following ions: aluminum, ferrous iron, calcium, magnesium, potassium, sodium, ammonium, carbonate, chloride, nitrite, and phosphate.

LITERATURE CITED

1. NOYES, A. A., Qualitative chemical analysis of inorganic substances. Ninth edition, pp. 190. The MacMillan Company, New York. 1924.
2. SCOTT, W. W., Standard methods of chemical analysis. Third edition, pp. 714, figs. 74, pls. 3. D. Van Nostrand Company, New York. 1922.

A COMPARISON OF THE TOXICITY OF PARA-DICHLOROBENZENE AND NAPHTHALENE TO THE CONFUSED FLOUR BEETLE (*TRIBOLIUM CONFUSUM* DUV.) (COLEOPTERA)

By RUSSELL S. LEHMAN, *Iowa State College, Ames, Iowa*

ABSTRACT

Large numbers of *Tribolium confusum* were treated under controlled conditions with naphthalene and para-dichlorobenzene. The apparatus consisted chiefly of a closed system in which air was drawn over sulfuric acid to give the desired humidity and then through the compound before going through the exposure bottles. The entire system was confined in a constant temperature chamber maintained at 30° C. Saturated para-dichlorobenzene acts as a strong anesthetic to *Tribolium confusum*. On the basis of the time required to kill 50% of the insects, naphthalene was found to be from ten to fourteen times as toxic to *Tribolium confusum* as para-dichlorobenzene at the same concentration.

Practically all of the early workers on insect fumigants determined the minimum concentration required to kill 100% of the insects in a fixed period of time. Moore (1917a, 1917b) determined the concentration of various benzene derivatives required to kill 5 house flies in 400 minutes.

Jewson and Tattersfield (1922) found that naphthalene at saturation had no apparent effect on mites after 16 hours. Para-dichlorobenzene at saturation anesthetized them after 3 or 4 hours and after 16 hours all were so affected that none recovered after exposure to air.

Tattersfield, Gimingham, and Morris (1925) found that naphthalene had a more toxic action than para-dichlorobenzene on *Aphis rumicis* L.

Strand (1930) exposed *Tribolium confusum* to various compounds at a constant temperature. He considered thirty insects enough for each

test since Trevan (1927) used thirty mice in his experiments with cocaine and stated: "A significant increase of accuracy above that given by this group number is only obtained by the use of greatly increasing numbers of animals; whilst diminution of the group number below 30 leads to a very rapidly increasing error." Trevan injected the mice intravenously and varied the doses according to the weight of the animals. Whether or not a comparison can be made between Trevan's method and a method whereby 30 insects are picked at random regardless of size is open to question. Both Trevan (1927) and Strand (1930) use the 50% kill point or the concentration which will kill 50% of the animals. This seems to be the best point statistically for a comparison of toxicities.

Bottimer (1929) compared the effect of naphthalene and para-dichlorobenzene as repellents to clothes moth larvae. He found that neither compound had any apparent effect upon the larvae when left exposed in an ordinary sized room.

Fleming (1925) compared the action of naphthalene and para-dichlorobenzene as soil insecticides for control of the Japanese beetle. He found that naphthalene was more effective against the larvae than para-dichlorobenzene, but that the latter compound was more effective than the former against the egg and adult.

Description of Apparatus. The apparatus used in these experiments is similar to that employed in the war gas experiments and in Allison's (1928) work with hydrocyanic acid.

Figure 83 is a diagram of the apparatus employed in the comparison of the toxicity of para-dichlorobenzene and naphthalene. In order to illustrate the operation of the apparatus, the course of the air through the system will be traced. The air enters at (a) and the total flow is recorded by the clock meter (b). Bottles (c), (d), and (f) of two and one-half liter capacity contain sulfuric acid of sufficient density, 1.320 at 30°C., to give a relative humidity of 60 to 65 per cent. Bottles (e) and (g) contain glass wool to take up the acid spray. The flow of the air over the para-dichlorobenzene in the tube (j) of the generating train is controlled by the screw clamp (h) and shown on the flow meter (i). A three liter bottle (k) mixes the vaporized para-dichlorobenzene of the generating train with air from the dilution train. The exposure train in which the insects were placed consists of six 250 c.c. flasks (l, m, n, o, p, and q). The tube (r) contains naphthalene which was used to check the total flow of air through the system. The flow meter (s) gives the total flow of air and should be the same as the clock meter (b). The screw clamp (t) regulates the air through the entire system. The 15

liter vacuum bottle (u) was used to steady the flow of air. A two and one-half liter bottle (w), partly filled with water, acts as a suction regulator with the screw clamp (v) helping to control the amount of suction. The water suction pump was located at (x).

When a saturated atmosphere of para-dichlorobenzene or naphthalene was desired, the generating train was removed from the system and the tube of para-dichlorobenzene or naphthalene was placed at (y). The dilution train then became the generating train.

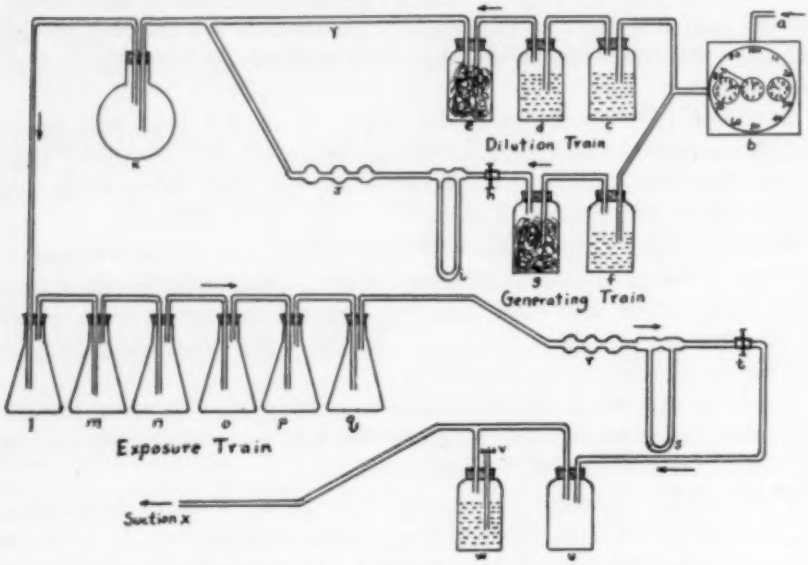

FIG. 83.—Diagram of apparatus for toxicity comparisons.

The entire apparatus was confined in a constant temperature chamber at a temperature of 30°C. The temperature was controlled by the use of a mercury thermo regulator and a mercury relay operated by a six volt radio battery and connected to the regular 110 volt alternating current with light bulbs as a source of heat. The air in the chamber was kept in motion by the use of an electric fan.

The humidity through the system was determined by the use of wet and dry bulb thermometers and checked very closely with the calculated humidity that should be obtained with sulfuric acid of the density contained in the humidity bottles used.

METHOD OF PROCEDURE. *Tribolium confusum* Duv. was used in all of the experiments. The insects were bred in battery jars containing whole wheat flour at a temperature of 30°C., maintained by a constant

temperature chamber. A relative humidity of 60 to 70% was obtained by the use of a saturated sodium chloride solution.

In the first experiments only 20 insects were used in each flask, but the number was increased to fifty, and finally most of the experiments were performed with 100 insects in each flask or 600 insects at each exposure. A total of more then 25,000 insects were used in this investigation. An exact number of insects was obtained in most cases by allowing the insects to walk up a white cardboard and then carefully counting them into each flask. None of the insects were used more than once.

The flow meter, which had been calibrated against a gas clock meter, was set so that a flow of about 60 liters an hour was maintained when a saturated atmosphere was desired. The tube containing the naphthalene or para-dichlorobenzene was first weighed on a chemical balance and then placed in the system. This tube was reweighed after the completion of the experiment. The loss in weight was the amount of naphthalene or para-dichlorobenzene taken up by the air. The amount volatilizing in a certain volume of air checked very closely with the calculations published by Roark and Nelson (1929). The gas clock meter was placed in the system to record the flow of air when the exposure continued over a long period of time. The successive results obtained with naphthalene checked so closely that it was decided to use naphthalene in the system as a check in obtaining the total flow of air.

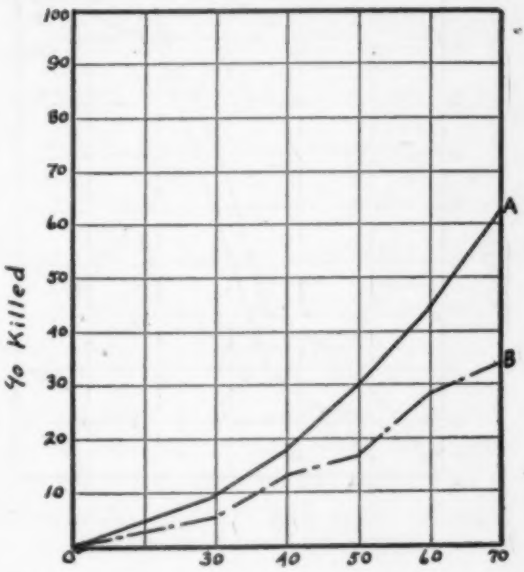

FIG. 84.—Para-dichlorobenzene at saturation, 0.000078 moles per liter. At each point plotted, 250 insects were used. Time in minutes.

At the beginning of the experiment air was passed over the compound from 30 minutes to one hour before the insects were placed in the exposure bottles. This was done so that the air and the compound in the mixing bottle would be of the proper proportion to pass immediately into the exposure bottles when the insects were placed therein.

At the conclusion of the experiment the insects were removed immediately from the fumigatorium and after examination they were placed in bottles containing whole wheat flour. These bottles were placed in a constant temperature chamber as previously described under the breeding of cultures. The first careful examination was made at about 24 hours after exposure. Insects that were unable to walk at this time were considered dead. All of the insects were then returned to the bottles containing whole wheat flour and examined one week later. Where the exposure lasted for several days, controls containing the same number of insects were carried along under the same conditions except that they were not exposed to the compounds. All the experiments were conducted in a constant temperature chamber where the temperature never varied more than 0.2°C.

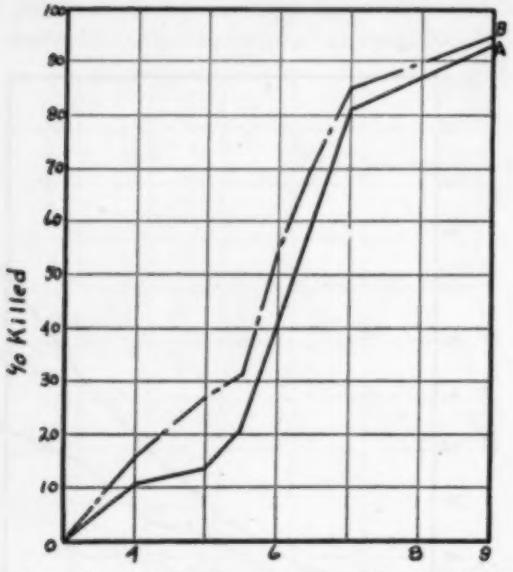

FIG. 85.—Naphthalene at saturation, 0.0000067 moles per litre. Time in hours.

The naphthalene and para-dichlorobenzene used in all of the experiments were purified by dissolving in ether, filtering, and allowing to crystallize. The excess ether was evaporated before the compounds were used.

DISCUSSION AND RESULTS. In making the observations, it was necessary to select some criterion of death. The writer called an insect dead at the 24 hour observation if it was unable to walk. In all cases, with the exception of para-dichlorobenzene at saturation, insects that could not walk at the 24 hour observation never recovered sufficiently to be counted alive at the one week observation. The anesthetic property of the para-dichlorobenzene was so strong that the insects were still anesthetized when the 24 hour observation was made but a large number recovered before the one week observation. This can readily be seen by referring to Table 1. Jewson and Tattersfield (1922) also noticed this anesthetic property of para-dichlorobenzene on mites.

This result was not obtained when the concentration of para-dichlorobenzene was reduced to the same concentration as naphthalene. The comparison was made on a molecular basis. The concentration of naphthalene at saturation (30°C.) was 0.000852 grams per liter or 0.0000067 moles per liter. Para-dichlorobenzene at the same concentration on a molecular basis will contain 0.000985 grams per liter since the molecular weight of para-dichlorobenzene is 147 and that of naphthalene 128.

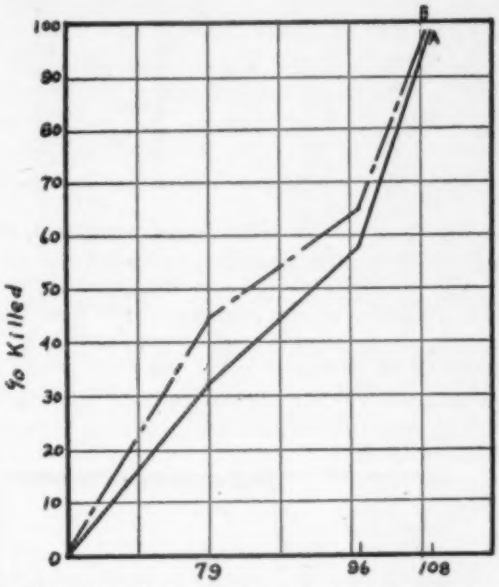

FIG. 86.—Para-dichlorobenzene at the concentration of 0.0000067 moles per liter. Time in hours.

As it was necessary to expose the insects for a much longer time with para-dichlorobenzene at the low concentration to obtain the same per cent kill as that obtained with naphthalene, the insects were finally killed instead of being just anesthetized. In all cases a larger number were dead at the one week observation than at the 24 hour observation. Natural death will not account for this difference since control samples were run along with the others and deductions were made for deaths found in the control. This difference will readily be noticed by referring to Table 3 and then to Table 1.

*TABLE 1. RESULTS WITH PARA-DICHLOROBENZENE AT SATURATION, 0.000078 MOLES PER LITER

Time in min.	Observation after 24 hrs. No. of expts.	Ave. % killed	S.D.	Observation after 7 days Ave. % killed	S.D.
30	5	9.6	± 6.5	6.4	± 5.9
40	5	18.8	±10.2	13.2	± 8.8
50	5	30.0	±19.5	17.6	±13.4
60	5	44.0	±15.7	28.4	±11.5
70	5	62.0	±13.3	33.6	±19.6

*Fifty insects were used in each experiment. S.D. standard deviation $\sigma = \sqrt{\frac{\Sigma d^2}{N-1}}$

TABLE 2. RESULTS WITH NAPHTHALENE AT SATURATION, 0.0000067 MOLES PER LITER

Time in hrs.	Observation after 24 hours			Observation after 7 days	
	No. of expts.	Ave. % killed	S.D.	Ave. % killed	S.D.
4	6	10.5	±8.3	15.7	±4.5
5	6	13.0	±4.1	26.8	±4.9
5½	6	20.3	±5.0	31.0	±3.9
6	6	40.7	±5.6	53.7	±3.7
6½	6	60.7	±8.1	70.2	±8.0
7	6	81.8	±7.4	84.5	±6.7
9	6	92.7	±6.6	94.2	±6.2

One hundred insects were used in each experiment.

Where the control samples were run, the calculations were made according to the method employed by Abbott (1925) for computing the efficiency of insecticides. $\frac{x-y}{x} .100$ = per cent efficiency of the insecticide or in this case the per cent actually killed. x = per cent living in control. y = per cent living after exposure.

The results obtained with para-dichlorobenzene at the same concentration as naphthalene as shown in Table 3 (A) differ quite widely from those shown in Table 3 (B). There are several possible explanations of this wide variation. It might be due to the difference in seasons as the results given in Table 3 (B) were obtained in the fall of 1929 whereas the results given in Table 3 (A) were obtained during the winter of 1930. Holt (1916) found the cockroach to be more resistant during the fall of the year. It may be possible that *Tribolium confusum* is more resistant at this season of the year. The difference may be due to the difference in the anesthetic property of the para-dichlorobenzene.

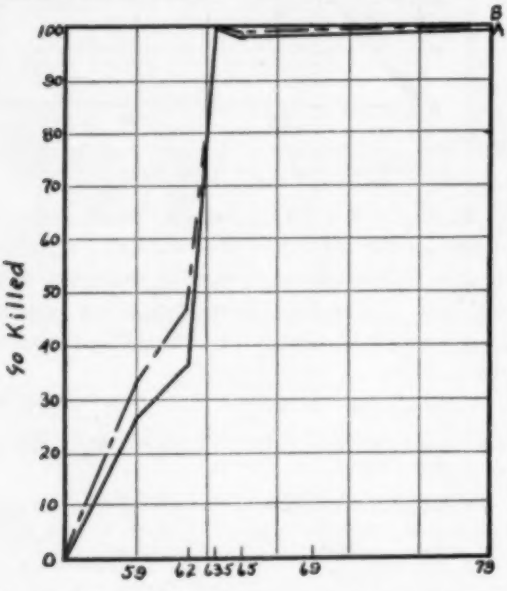

FIG. 87.—Para-dichlorobenzene at the concentration of 0.0000067 moles per liter. Time in hours.

TABLE 3. RESULTS WITH PARA-DICHLOROBENZENE AT THE SAME CONCENTRATION AS NAPHTHALENE AT SATURATION, 0.0000067 MOLES PER LITER

Time in hrs.	No. of expts.	Observation after 24 hours: Ave. % killed in control	Ave. % actually killed	S.D.	Observation after 7 days: Ave. % killed in control	Ave. % actually killed	S.D.
(A)							
59	6	2.2	26.6	±3.8	2.7	32.3	± 4.4
62	6	2.2	37.0	±7.3	2.7	46.6	±10.3
63½	6	2.2	100.0	—	2.7	100.0	—
65	6	4.3	98.1	± 1.6	5.3	99.3	± 0.9
69	6	4.3	98.0	± 1.6	5.3	99.5	± 0.9
73	6	5.0	98.6	± 1.7	6.3	98.6	± 1.9
(B)							
79	6	6.2	32.1	± 5.9	7.8	44.0	± 6.7
96	6	4.0	58.6	± 4.3	5.7	64.0	± 1.8
108	6	8.8	98.0	± 0.8	12.3	98.3	± 1.3

Two hundred insects were used in each experiment, 100 insects exposed and 100 insects in each control. The experiments in part (B) were performed two months previous to those given in part (A).

When the insects were examined immediately after being removed from the fumigatorium after being subjected to the influence of the para-dichlorobenzene or naphthalene, they were able to move their legs and antennae and in some few cases some were able to walk. It was noticed that the meta-thoracic legs were the first to be acted upon by the anesthetic. The insects in many cases were able to walk with the first two pairs of legs and drag the meta-thoracic legs along.

In a number of cases the females laid a large number of eggs soon after they were placed in the fumigatorium containing para-dichlorobenzene. At other times during exposure to the same compound, the ovipositor was extended and in some cases it was never drawn in after recovery. When the exposures extended over a long period of time and the final per cent killed was high, the insects during the latter part of the exposure had a convulsive reaction which consisted of periodic movements of the legs and antennae every few seconds.

Based on the time required to kill 50% of the insects, taken from the results summarized in Tables 2 and 3 (B) and shown graphically in Figs. 85 and 86, naphthalene appears to be 14 times as toxic to *Tribolium confusum* as para-dichlorobenzene of the same concentration. When a comparison of the results as compiled in Tables 2 and 3 (A) and shown in Figs. 85 and 87 is made, naphthalene appears to be only ten times as toxic. Therefore, on the basis of the time required to kill 50% of the insects, naphthalene is from 10 to 14 times as toxic to *Tribolium confusum* as para-dichlorobenzene at the same concentration.

The writer wishes to acknowledge his indebtedness to Dr. C. H. Richardson for suggesting this problem and for making many helpful criticisms as the work progressed. Many thanks are due to Dr. R. M. Hixon for information regarding the apparatus and its operation.

LITERATURE CITED

ABBOTT, W. S. A Method of Computing the Effectiveness of an Insecticide. Jour. Econ. Ent. Vol. 18, pp. 265–267. 1925.

ALLISON, J. B. Studies on the Toxicity of Hydrocyanic Acid. Iowa State Coll. Jour. of Sic. Vol. 2, pp. 245–252. 1928.

BOTTIMER, L. J. Notes on Para-dichlorobenzene and Naphthalene as Repellents against Clothes Moth Larvae. Jour. Econ. Ent. Vol. 22, pp. 570–573. 1929.

FLEMING, W. E. The Comparative Value of Carbon Disulfide and Other Organic Compounds as Soil Insecticides for Control of the Japanese Beetle. N. J. Agr. Expt. Sta. Bul. 410, pp. 1–29.

HOLT, J. H. The Cockroach; Its Destruction and Dispersal. A Comparison of Insecticides and Methods. Lancet 1916, pt. 1, pp. 1136–1137. 1916.

JEWSON, S. T. and TATTERSFIELD, F. The Infestation of Fungus Cultures by Mites. Its Nature and Control, together with some Remarks on the Toxic Properties of Pyridine. Ann. App. Biol. Vol. 9, pp. 213–240. 1922.

MOORE, W. Toxicity of Various Benzene Derivatives. Jour. Agric. Res. Vol. 9, pp. 371–381. 1917a.

——— Volatility of Organic Compounds as an Index of the Toxicity of their Vapors to Insects. Jour. Agric. Res. Vol. 10, pp. 365–371. 1917b.

ROARK, R. C. and NELSON, O. A. Maximum Weight of p-dichlorobenzene and Naphthalene which can Exist in Vapor Form in a 1,000 cu. ft. Fumigating Chamber. Jour. Econ. Ent. Vol. 22, pp. 381–387. 1929.

STRAND, A. L. Measuring the Toxicity of Insect Fumigants. Jour. Ind. Eng. Chem. Analyt. Ed. Vol. 2, pp. 4–8. 1930.

TATTERSFIELD, F., GIMINGHAM, C. T., and MORRIS, H. M. Studies on Contact Insecticides. Part III, A Quantitative Examination of the Insecticidal Action of the Chloro-Nitro- and Hydroxyl Derivatives of Benzene and Naphthalene. Ann. App. Biol. Vol. 12, pp. 218–262. 1925.

TREVAN, J. W. The Error of Determination of Toxicity. Proc. Roy. Soc. London B 101, pp. 483–514. 1927.

FLY TRAPPING ON THE RANGES OF THE SOUTHWEST

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ABSTRACT

The use of fly traps on the stock ranges of the Southwest has become somewhat extensive. In 1928 stockmen estimated the loss during that year from the screw-worm fly and fleece-worm fly to be $10,000,000. In 1929 the Bureau of Entomology, in cooperation with a local ranchmen's trapping association, conducted tests upon the effectiveness of systematic fly trapping in reducing the number of flies on an area of approximately 200 square miles of ranch land in Menard County, Texas. In comparison with a similar untrapped area a reduction of 36.2 per cent of the fly population in the trapped area by reason of the trapping was indicated. The most effective bait was found to be two pounds of fresh meat to which is added two gallons of water, and nicotine sulphate at the rate of four cubic centimeters per gallon of water. The frequency of renewing baits and refilling bait pans with water is dependent upon weather conditions.

While systematic organized fly trapping activities give promise of a distinct reduction in screw-worm and fleece-worm losses, the present prospects are that effective control can only be brought about by a combination of destruction of carcasses and trapping supplemented by approved ranch practices, and the possible utilization of parasites and predators of these blow flies.

The Bureau of Entomology announced a few years ago that great numbers of the screw worm fly, *Cochliomyia macellaria* Fab., and the black blowfly or so-called fleece-worm fly, *Phormia regina* Meig., might be captured in traps, and suggested the use of traps as a supplementary control measure for these flies. Since this announcement the use of flytraps has become somewhat extensive on the ranges of the Southwest. Under the direction of county agents, ranchmen are organized into associations for cooperative flytrapping. Some of the organizations employ a "trapper," who devotes his time to the care of the traps. Others have arranged for the individual ranch operators to care for the traps. In addition to these, individual ranches are being trapped independently by their owners or lessees. Conservative estimates based on the number of traps manufactured by tinners indicate that approximately 15,000 traps are being operated on ranches in southwestern Texas. This section, as well as other sections in the livestock area of the Southwest, is constantly increasing the number of traps in use and extending their operation over untrapped territory.

Reduction of losses from the screw worms and fleece worms is claimed by the majority of the organizations or individuals using traps, and this, no doubt, accounts for the extensive employment of this method of dealing with this important problem.

Losses from Screw-Worm and Fleece-Worm Cases. In November, 1928, nearly 1,000 of the most prominent ranchmen of the Southwest met to discuss ways and means of combating the screw-worm fly and the fleece-worm fly. For that year they estimated the loss to the industry from this source to be $10,000,000. During the early fall of 1928 some sections suffered rather heavy losses, although as a whole that year cannot be considered as an unusual one, inasmuch as the average annual loss is generally considered as amounting to about that figure.

Although from the point of view taken herein the part played by flies in the causation of myiasis in animals is of major importance, it must also be remembered that flies exert in many ways a marked influence upon the welfare of the stockmen.

Recent Development of Range Trapping. While the trapping of flies on ranches has been practiced during the active fly season for a

period of 4 or 5 years, unfortunately, no uniform or accurate records have been made from which to ascertain the degree of control which may be obtained by the use of traps.

The Bureau of Entomology, in cooperation with a well organized trapping association under the direction of County Agent W. R. Nisbet, in Menard County, Texas, started the task of securing accurate and comprehensive records on flytrapping during the fly season of 1929. Valuable and interesting information is being secured, which, when complete, should determine, in some degree at least, the value of flytrapping under practical conditions. The investigation under way has not as a whole progressed sufficiently during the past season to enable definite conclusions to be drawn. Certain phases of it, however, have given us information which we consider worthy of report at this time.

THE TEST AREA. The test upon which this report is based covers an area of approximately 200 square miles of typical ranch land situated in the northwestern part of Menard County, Texas. The elevation is from 2,000 to 2,200 feet above sea level. The rainfall is approximately 22.8 inches per year for an average of six years, according to available unofficial local records. Menard County lies in that section of the plains known as the Edwards Plateau. The area under consideration lies along the north side of the San Saba River, which properly begins in springs in the vicinity of Fort McKavett situated at the southwestern corner of this area. The topography of this area ranges from gently rolling and hilly to moderately rough and broken. The ridges throughout the area are very stony. Shallow, dry, rocky draws separate the hills. The vegetation consists of scattered low live oak, chinoak and mesquite, and various small thorny shrubs. Various weeds and grasses grow luxuriantly along the draws and hillsides when rainfall is sufficient. There is very little cultivation except along the river. Although the topography is usually not too rugged for the cultivation of small patches in this area, the presence of rocks on the surface of the shallow soil prevents its use for this purpose.

The environments encountered in the test area are very similar to those existing over millions of acres of ranch land in the livestock-raising districts of western and southwestern Texas. There are, of course, many local or sectional variations in any area of this size. Some of these were met with in the area under consideration. Range management in the test area is similar in most respects to that practiced throughout much of the region where screw-worm and wool-maggot

damage is a major problem. For this reason the results that are being obtained in the area in question will be applicable to much of the affected area.

The abundance of all flies and the per cent of the total fly population represented by each species have been carefully studied in this area during the period of greatest fly activity, March 1 to November 1. Although certain species of flies, particularly of the genera *Calliphora*, *Cynomyia*, and *Phormia*, are present in considerable numbers during the winter months, little injury is caused by them. For this reason trapping was discontinued during these months.

Traps and Their Operation. There are 313 traps located in the test area, or 1 trap to approximately 407 acres. This ratio differs somewhat on individual ranches, but the distribution of the traps is rather uniform as a whole.

Baiting of the traps during the whole season was carried out systematically and in accordance with the best results previously obtained in extensive field experiments. Such experiments have proven that the most effective bait, considering availability and economy, consists, for each trap, of 2 pounds of fresh meat to which is added 2 gallons of water and nicotine sulphate at the rate of 4 cubic centimeters to a gallon of water. The addition of nicotine sulphate inhibits the develoment of larvae and does not interfere with the normal decomposition of the meat or reduce its attractiveness to flies. The meat which was utilized in the experiment reported on in this paper was obtained from old and inferior goats and sheep which were culled from herds within the test area and were slaughtered when needed. The frequency with which baits are renewed and the bait pans refilled with water between the renewals of the baits is largely dependent on weather conditions. The rate of decomposition of the meat and the evaporation of the water are greatly accelerated during the hot weather of the summer months. In this test it was found necessary to renew the baits at 15-day intervals during the summer months and at from 20 to 25 day intervals during the spring and fall. In order to prevent the drying of the baits, which renders them unattractive, it was necessary to refill the bait pans with water every 7 to 9 days during the summer months, and every 10 to 12 days during the cooler months.

Quantity and Species of Flies Caught. At intervals of six weeks the flies in each trap were removed and measured. A total of 8,533 quarts of flies was trapped in the test area during the period from March 15 to November 1. At each time the traps were emptied samples were taken from traps representing all parts of the area. Two thousand

five hundred flies taken at random from each of these composite samples were determined as to species and sex. Table 1 shows the species taken, together with the per cent of each species and the proportion of the sexes.

TABLE 1. SPECIES OF FLIES CAUGHT, PERCENTAGE OF TOTAL CATCH REPRESENTED BY EACH SPECIES, AND THE PROPORTION OF THE SEXES

Species	Number of specimens	Per cent of total	Proportion of the sexes	
			Per cent males	Per cent females
Cochliomyia macellaria Fab	8,506	68.048	35.69	64.31
Cynomyia cadaverina Desv	29	.232	6.89	93.11
Calliphora coloradensis Hough	33	.264	27.27	72.73
Calliphora viridescens Desv	6	.048	0.00	100.00
Lucilia sericata Meig	2	.016	0.00	100.00
Lucilia unicolor Town	777	6.216	30.83	69.17
Phormia regina Meig	2,102	16.816	41.96	58.04
Musca domestica Linné	8	.064	25.00	75 00
Synthesiomyia brasiliana B. & B	72	.576	10.00	90.00
Muscina stabulans Fall	3	.024	0.00	100.00
Neomuscina tripunctata Vaw	1	.008	0.00	100.00
Sarcophaga spp.*	932	7.456	49.50	50.50
Ophyra aenescens Wied	4	.032	75.00	25.00
Ophyra leucostoma Wied	4	.032	0.00	100.00
Fannia trimaculata Stein	1	.008	0.00	100.00
Stenopterina brevipes Fab	2	.016	0.00	100.00
Tachinid spp	13	.104	11.12	88.88
Miscellaneous	5	.040	20.00	80.00
Total	12,500	100.000		

*At least 40 species were represented.

DISCUSSION OF TABLE 1. In analyzing Table 1 it will be noted that the two species *C. macellaria* and *P. regina*, which are responsible for practically all cases of myiasis in domestic animals, constitute nearly 85 per cent of the total of all species caught. The senior author has on several occasions reared *Sarcophaga robusta* Ald. from larvae taken from wounds of animals and on one occasion also *Cynomyia cadaverina*. However, these cases are rather rare, and can not be considered of economic importance. In the proportion of the sexes the table shows that females of nearly all of the species caught were represented in much greater numbers than the males. This is no doubt due to the fact that the strong odors emanating from the decomposing meat baits not only attract these meat-breeding species of flies for feeding, but also attract females for oviposition. That the proportion of the sexes indicated in the table does not exist normally in nature has been demonstrated by us with breeding experiments carried out in the field during the past season. Pupae and mature larvae collected near carcasses which had served for their supply of nourishment and which they had left voluntarily were placed in suitable breeding cages. The resulting adults were nearly all *C. macellaria*, and the sex of all the specimens

of this species was carefully determined. Out of a total of 6,150 specimens so produced, 3,139, or 51.04 per cent, were males and 3,011, or 48.96 per cent were females. We have no logical reason for believing that the sexes of other meat-breeding species of flies do not develop in nature in the same proportion as those of *C. macellaria.*

Seasonal Population and Its Reduction in the Test Area. Studies of comparative abundance were carried out in the test area and in a check area located 15 to 30 miles away. For these studies beef liver in an early state of decomposition and very attractive to flies, was exposed in quart fruit jars for definite periods. The number of flies of each species which entered the jars was recorded. Ten exposures in widely separated places in each of the two areas were made on the same day and hour at regular intervals during the trapping period. The results obtained from these tests showed an average reduction throughout the period of trapping of 36.2 per cent of the total fly population in the trapped area as compared with that in the untrapped area.

The reduction percentage given does not include natural reduction from climatic or other causes. The untrapped check area provided the basis for the reduction computation.

Since no other determinable factors of importance in relation to the reduction of flies existed in the test area, it seems probable that the 36.2 per cent reduction was due to the trapping of the 8,533 quarts of flies. If we add to this the theoretical 63.8 per cent, or 15,038 quarts of flies which escaped the traps, as shown by the jar tests, we have a total of 23,571 quarts of flies present during the active season in a relatively small area. By reducing this quantity to the actual numbers of flies contained therein, some idea can be obtained of the enormous numbers of these unwelcome pests inhabiting our extensive livestock-producing sections of the Southwest. Based on an actual count of 11 quarts of flies, which averaged 9,950 to the quart, the total fly population of the trapped area was estimated as 234,531,450.

For a long time the stockmen have been well aware of the potential source of damage that exists in this enormous number of flies. Their efforts in the past toward the control of this pest by trapping flies have been mostly along ineffective lines, on a small scale, and with no cooperative action. Consequently very little good has been accomplished.

With the introduction of organized effort the results of flytrapping so far recorded indicate that there is some hope for a distinct reduction of screw-worm losses. To those most familiar with the problem it is not conceivable, however, that trapping alone will be the solution. The

Bureau of Entomology continues to advocate the prompt destruction of all carcasses and other preventive measures.

It is our opinion that effective control can only be brought about by a combination of destruction of carcasses and trapping, supplemented by the general adoption of ranch practices which will tend to avoid screw-worm and fleece-worm attack on livestock, and possibly also by the utilization of parasites and predators of the immature stages of these insects.

THE MORE IMPORTANT INJURIOUS INSECTS OF HAITI

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ABSTRACT

The paper lists under a host or a grouping the more important insect pests of Haiti by scientific name, family, and with a brief note of abundance so far as known. A brief summary of the main geographical, phenological and agricultural features of Haiti is given. The insect life shows a mingling of temperate and torrid zone forms. Some insects one might expect to find in Haiti but which are not known to occur are also mentioned.

Upon coming to Haiti, July 15, 1928, the senior writer was forced to familiarize himself with the more important economic insects of the country. Perhaps others also will be interested in knowing what they are, so this brief summary is presented herewith.

We have drawn freely upon information accumulated by Dr. Geo. N. Wolcott, formerly Entomologist of the Service Technique, particularly as recorded in his recently completed text book, in his annual reports, and in unpublished monthly reports. Many of the determinations are from the department collection and have been made through his efforts by the U. S. National Museum authorities and those at the British Museum. Acknowledgment is made to these sources of information utilized in this report. Dr. H. L. Dozier also has supplied some records and determinations.

GEOGRAPHY AND CLIMATE OF HAITI (WOODRING 1924). Haiti and Sto-Domingo occupy the island of Hispaniola which is the second largest island of the West Indies. Haiti occupies the western and more mountainous third. Its area is 10,204 square miles, approximately equal in size to the State of Maryland. The island is located just within the Tropics lying between 68°20′ and 74°30′ longitude and 17°39′ and 20° North latitude.

The climate of Haiti is tropical though it is a rather mild tropical climate. Table 1 gives a summary of weather data.

TABLE 1. METEOROLOGICAL DATA FOR PORT-AU-PRINCE, HAITI
ALTITUDE: 37 METERS

Month	Mean temp. centigr.	Monthly temperature range. Minimum and maximum with years	Mean month. rainfall	Range of rainfall. Min. and maximum with years. In millimeters
Jan.	25.7	24.5 (1910)—26.3 (1916)	32.2	0 (1887)—161.8 (1886)
Feb.	25.8	25.2 (1910)—26.3 (1913)	57.9	0 (1903)—230.9 (1902)
Mar.	26.3	24.7 (1910)—27.1 (1913)	93.8	7.6 (1900)—314.7 (1904)
Apr.	26.4	25.6 (1913)—27.2 (1916)	162.4	23.0 (1885)—362 (1866)
May	27.2	26.1 (1913)—27.8 (1914)	249.8	92.0 (1885)—464.6 (1889)
June	28.2	27.9 (1916)—28.8 (1915)	105.5	10.8 (1904)—346.6 (1916)
July	28.8	27.7 (1916)—29.6 (1914)	69.5	1.8 (1894)—150 (1866)
Aug.	28.5	28 (1909)—28.9 (1915)	139.4	27.4 (1919)—271.5 (1915)
Sept.	27.8	27.2 (1909)—28.4 (1914)	184.7	29 (1883)—455.6 (1910)
Oct.	27.1	26.6 (1912)—28.1 (1915)	169.6	51.5 (1886)—353.4 (1911)
Nov.	26.2	26 (1916)—27.2 (1915)	85.7	4.2 (1889)—246.9 (1909)
Dec.	25.6	24.7 (1916)—26.6 (1915)	35.0	0 (1918)—161.2 (1898)

Temperatures from Geology of Haiti, 1924, p. 38. Covering years 1909–1916 Rainfall from same, p. 47. Covering years 1863–1919. (Note: 25.4 mm. = 1 inch Degrees centigrade times 9:5+32 degrees = °F.) See Bulletins Hydrographiques 1–6 published by Direction Générale des Travaux Publics for annual summaries covering 1922–1928.

CROPS OF HAITI. Coffee is the most important crop of Haiti and fully three-fourths of the export revenue comes from this crop. Since coffee trees in Haiti require shade, it is grown chiefly in wooded areas in the mountains.

Cotton which is second in importance is produced on a perennial shrub. When untrimmed it may grow to be 8 or 10 feet high.

Logwood or dye wood (*Haematoxylon campechianum* L.) locally known as "campêche" is also an important export. This tree was introduced probably from Yucatan many years ago and now grows wild on the plains and the foot hills. It is the chief honey plant of Haiti. Gaiac and mahogany are other important trees.

Other crops somewhat in order of their importance are: sugar cane (also largely surviving from French cultivation, though lately several new varieties of cane have been brought from Porto-Rico), tobacco, rice, red beans, corn (field variety only), sisal, manioc, peanuts, sesame, petit-mil (a native variety of grain sorghum resembling shallu), and feterita.

Among the fruits, should be mentioned several varieties of mangos, papayas, quéneppes (*Melicocca bijuga*), mombins (*Spondias mombin*), citrus, including limes, oranges and grape fruits, cacao, apples and peaches (the latter two of a very poor quality and only in the higher altitudes), pine-apples, guavas, caymites, corosols, cocoanuts, cashew, bananas, plantains, avocadoes, and abricots (*Mammea americana*).

Of vegetables there are many, but string beans, carrots, cabbage, beets, tomatoes, sweet potatoes, yams, very small Irish potatoes, French

melons (musk melons), water melons (of poor quality), malanga, breadfruit, peppers, beets, radishes, turnips, lettuce and mirlitons (*Sechium edule*), are the most important.

There is therefore a mingling of temperate zone and tropical vegetation, particularly at the higher altitudes. One also finds a mingling of insects of these two regions.

A List of the More Important Insect Pests by Crops.

Coffee Insects

Apate franscisca Fab. (Bostrichidae)—Coffee stem borer.

Cremon repentinus Rehn., Mss. species (Gryllidae)—A coffee cricket which deposits its eggs in a series of punctures in the new growth. The branches are so weakened that they may break when loaded with berries.

Leucoptera coffeella Stainton (Tineidae)—Coffee leaf miner. Not important.

Loberus insularis (?)—A small Cryptophagid beetle found working in the dried beans both in storage and on the bushes.

Anurogryllus muticus DeGeer and *Orocharis similis* Walk. are common crickets which eat the foliage.

Coccus viridis—Green coffee scale, the most serious scale insect of coffee.

Aleurocanthus woglumi Ashby—A black Aleyrodid common in poor coffee regions as at Pétionville.

Lasioderma serricornis Fab.—A Dermestid found damaging stored coffee at Jacmel.

Saissetia hemisphaerica Targ. (Coccidae)—Brown coffee scale.

Pseudicoccus nipae Mask. (Coccidae)—White coffee scale.

Aphids on roots—Identity unknown.

Cotton Insects.

Alabama argillacea Hub. (Noctuidae)—Outbreaks July to December.

Anomis doctorium Dyar (Noctuidae)—Similar to the above but less common.

Platyedra gossypiella Saunders (Gelechiidae)—Pink boll worm.—Causes little damage to native cotton but attacks severely the exotic imported varieties, such as Sea-Island, Meade, Pima and Upland.

Dysdercus andreae Linn. (Pyrrhcorridae)—Cotton stainer.—The most serious cotton insect of Haiti.

Aphis gossypii Glover—The cotton aphid—Very abundant and particularly serious on young cotton plants.

Hemichionaspis minor Maskell—Cotton scale—Present on most old cotton plants but probably does little damage.

Artipus psittacinus Gyllenhall—Cotton leaf chafer, small green scarab present in considerable numbers on many plants but doing little perceptible damage.

Nezara viridula Linn.—A fairly common Pentatomid. Feeds on young bolls and provides entrance for boll rot diseases.

Phyllophaga hogardi Blanch. (Scarabaeidae)—The common white grub of Haiti but not particularly serious on cotton.

Prodenia ornithogalli Guenée (Noctuidae)—Cotton cut worm or yellow striped Army worm—Sometimes goes from such weeds as *Boerhaavia erechtea* to cotton foliage and damages the foliage.

Pyroderces rileyi Wlsn. (Cosmopterygidae)—and *Loberus sp.* are cotton scavengers found in numbers in bolls injured by cryptogamic diseases. Also in insect excrement on other plants.

Solenopsis geminata Fabr., *D. pyramicus niger* Pergande, *Paratrechina longicornis* Latr. and *Monomorium destructor* Jerd are species of ants determined by Dr. M. R. Smith from cotton plants and other crops.

Nasutitermes spp.—Cotton termites which feed upon old stalks, roots and dropped bolls.

SUGAR CANE. (Varieties Native, Uba and P. O. J.)

Diatraea saccharalis Fab. (Crambidae)—The sugar cane moth borer is known to be abundant in only one field of P. O. J. cane.

Calisto pulchella Lathy (Satyridae)—The Sugar cane leaf worm.—Of little consequence.

Prenes nero Fab. (Hesperidae)—Not abundant.

Mocis repanda Fab. (Noctuidae)—Sugar cane looper. Sometimes present as an outbreak such as occurred in the Hasco fields, 1928.

Prepodes quadrivittatus Oliv. (Cucurlionidae)—Not common.

Laphygma frugiperda Sm. and A.—Damages young cane sometimes.

Pseudococcus calceolariae Mask.—A mealy bug occurring under the leaf sheaths. Common.

Aphis maidis Fitch—Common on young cane. Said to be the transmitters of sugar cane mosaic which is a serious cane disease.

Lachnosterna hogardi Blanch., *Lygyrus ebenus* De Geer, and *Strataegus quadrifoveatus* P. de B. are white grubs which do serious damage to the roots of cane.

Pseudococcus sacchari Ckll., the pink stalk mealy bug which occurs under leaf sheaths of cane, particularly of stalks which have gone down.

TOBACCO INSECTS.

Phthorimaea operculella Zeller (Gelechiidae)—Tobacco leaf miner—A very serious pest of young plants, particularly in the beds and when transplanted.

Psara periusalia Walk (Gelechiidae)—Tobacco leaf roller—Makes a tent of two leaves, feeds on the leaf surface within. Serious on young plants.

Protoparce sexta Johannsen (Sphingidae)—Tobacco horn worm—Very abundant and destructive.

Epitrix parvula Fab. *E. cucumeris* Harris and *Systena basalis* Duval are flea beetles (Chrysomelidae) which are very damaging at times to young plants.

Nezara viridula Linn. (Pentatomidae)—The pumpkin bug—is said to cause wilting of the buds.

Prodenia ornithogalli Guenée and *Feltia annexa* Treit. (Noctuidae) are tobacco cutworms particularly damaging to young plants.

Solenopsis geminata Fabr. (Formicidae)—These ants are particularly damaging to young plants in the beds. They also carry off newly sown seed.

CORN AND FETERITA

Laphygma frugiperda S. & A. (Noctuidae)—The Fall army worm—is very common and feeds on the hearts of these plants causing the rag worm injury.

Agrotis sp., a cut worm, is common on young plants, cutting them off.

Sitophilus oryzae L.—Rice weevil—and *Calandra granaria* L.—the common granary weevil—attack stored corn. The former is much more common than the latter.

Tribolium confusum Linn.—Confused flour beetle (Tenebrionidae)—is very abundant in stored grain of all kinds.

Heliothis obsoleta Fabr.—The corn ear worm—does not cause very great damage since the variety of corn grown is a hard flint type. It does not attack cotton bolls nor tomatoes as in the States.

Aphis maidis Fitch.—Corn leaf aphid—is very common on young plants.

Peregrinus maidis Ashmead (Fulgoridae)—occurs in great numbers on the young plants and *Cicadula maidis* De L. & W. (Cicadellidae) also in lesser number is found on the leaves of the plants.

Polistes crinitis Fabr. and *P. major* P. de B. are common. They gnaw the surface of the leaves and feed on the sweetish exuding sap.

SWEET POTATO INSECTS

Cylas formicarius Fabr. (Curculionidae)—The Sweet potato weevil—is present in practically all fields in Haiti and causes a bitter or spoiled taste in tubers attacked.

Euscepes batatae Waterhouse is another weevil which does the same kind of injury as Cylas but it is less important.

BANANA

Cosmopolites sordidus Germar (Curculionidae)—Banana root borer.—Widely distributed and serious.

PAPAYA

Aulacaspis pentagona Targ.—The West Indian peach scale—is very common, the older trees which are sometimes heavily encrusted with the scale.

Erinnyis spp. (Sphingidae)—Papaya leaf worms—are common but never serious. They are controlled by a Braconid parasite, *Apanteles americanus* Lep.

Prepodes 4-vittatus Oliv. (Curculionidae)—occurs particularly on young plants, but is rarely serious.

Toxotrypana curvicauda Gerst—Papaya fruit fly and *Anastrepha fraterculus* Wied (Trypetidae) which is the West Indian fruit fly—both attack the fruit of papaya. The former is serious in some localities, the latter is most common on mangoes, mombins and cirouelles.

ORNAMENTAL PLANTS

Cannas are attacked by a skipper, *Calpodes ethlius* Cramer, which severely damages the foliage. The greenish larvae turn over the margin of the leaves beneath which they feed and pupate. The eggs were found to be highly parasited by *Trichogramma minutum* Riley.

HOUSEHOLD INSECTS

Mosquitoes are abundant at various seasons of the year, particularly during the rainy season and in swampy localities. The common tropical house mosquito, *Culex quinquefasciatus* Say is perhaps the most abundant one throughout the year and is said to be the one responsible for Elephantiasis of which many cases occur.

Aedes aegypti Linn. is also very common but yellow fever has long since been banished. Dengue is very common particularly with new-comers to the island.

Aedes sollicitans Walk. and *A. taeniorhynchus* Wied. are common in homes.

Anopheles albimanus Wied. is the most common malarial mosquito though *A. grabhami* Theob. is also common. Malaria is very common, but adult Anopheles mosquitoes are quite uncommon.

A very small Oscinid fly, *Hippelates flavipes* Loew, is very annoying to people. The flies buzz very close to one's face but they do not bite.

Culicoides furens Poey, a biting Chironomid, is abundant and disturbing, particularly in moist grassy places.

House flies are singularly uncommon in Haiti. They were found breeding in piles of fermenting coffee hulls and in pulp from a sisal decorticating plant.

Psychoda albipuncta Will.—A large Psychodid fly—is common in bathrooms and was found breeding in great numbers in a septic tank.

Bed bugs are very common indeed and strangely go largely unfought by the natives.

Fleas on dogs are exceedingly common.

At Kenscoff the problem of the chigoe fleas is very important. Many of the peasants have their feet infested with fleas.

Termites are very serious pests in houses and on any kind of wood structures. Wolcott (1924) lists *Cryptotermes brevis* Walker as the common one in houses; *Nasutitermes morio* Lat. makes the large nests in trees and *N. pallidiceps* Banks attacks cane in the field. The numbers of winged termites which swarm out from residences during the first rains of August and September are almost unbelievable. It indicates something of the size of the colony of termites in one's home. Floors in many homes and public buildings such as the U. S. Field Hospital are kept heavily oiled to prevent termite attacks.

Cockroaches are very bothersome indeed in homes. The large American cockroach, *Periplaneta americana* Linn. is one of the most common and a smaller form, resembling the German roach which is *Supella supellectilum* Serv. is also abundant. Adults of another cockroach, *Epilampsa sabulosa* Walk. are common at lights in August and September.

Ants however are the most common of all the household pests, one or more species of Solenopsis being most common.

Garden Insects

A Pyralid leaf skeletonizer, *Pilocrocis tripunctata* Fab., is the most serious pest of beets in Haiti. Another member of this family, the pumpkin leaf worm, *Margaronia hyalinata* Linn., often seriously defoliates pumpkins, squashes and muskmelons during the winter months.

The southern cabbage looper, *Autographa* (*Plusia*) *simplex* is by far the worst cabbage pest in Haiti and if uncontrolled generally ruins the foliage.

Plant lice (*Aphis gossypii* Glover) are particularly severe on artichokes. The plants may be killed by them and leaves are often seen to be wilting because of their attacks.

Phthorimaea lycopersicella Bush. damages the foliage of tomatoes severely.

Phthia picta Drury (Coreidae)—taken feeding on tomato fruit.

Fundella sp.—A bean twig borer which bores into the stems from the tips, stopping growth. Very common and apparently new according to Heinrich.

Miscellaneous Insects

A large Cerambycid beetle, *Stenodontes exsertus* Oliv., more spectacular than injurious, occasionally occurs in the decaying trunks of kapok or mapou trees (*Ceiba pentandra*). The leaves of this tree are annually eaten by *Eulepidotis modestula* N. S., probably not by May beetles as Wolcott suspected (1928, p. 22).

The Palm leaf skeletonizer, *Homaledra saballela* Cham has recently been found to be a serious enemy of the latanye palms in Haiti. The damage to the foliage may be sufficiently severe to kill the trees.

Aspidiotus destructor Sig., Palm scale, a serious pest of palms, particularly coconut.

A species of *Empoasca*, determined as a new species by Dr. D. M. De Long, was found to be responsible for a destructive yellow disease of all varieties of beans in Haiti. (Smith and Barker, 1930).

Pseudococcus nipae Mask.—Coconut mealy bug—Especially serious on young royal palms.

Chrysomphalus aonidum Linn.—Florida red scale—Serious on all palms.

Aulacaspis pentagona Targ. is a common semi-burrowing scale very destructive to a large leafed porch vine (*Pipex pentatum*).

A species of Mirid, determined as *Cyrtopeltis tenuis* Reut. by Dr. H. K. Knight, is an important pest of tomatoes.

Two species of bee moths occur in Haiti; the common one, *Galleria melonella* Linn., and a smaller wax moth, *Corcyra cephalonica* Stt. These two insects are very destructive to combs and weak colonies.

A small Tineid case bearer, *Tinea uterella* Wlsm., is common on the plastered walls of homes. The larvae make flat gray silken oblong sacks which are covered with sand. They feed upon insect remains but probably do no damage.

The tips of the branches of manioc are often severely damaged during February by a Sapromyzid fly, *Lonchaea chalybea* Wied.

Corythaica monacha Stahl. (Tingidae)—The egg-plant lace bug is the most common and most destructive of egg-plant insects.

Psara bipunctalis Fabr. is a webworm, which in larval appearance and habits closely resembles the garden webworm of the U. S. It is common each year on some weeds (*Amaranthus* sp.)

Megachile multidens Fox is a leaf cutting bee very common in buildings.

The Haitian insect fauna is particularly rich in species of Sphingidae, *Celario lineata* Fab., the white-lined Sphinx is particularly abundant. It feeds most commonly on *Boerhaavia*, a species of weed.

Some Serious Tropical and Subtropical Insect Pests not Known to Occur in Haiti

The Cotton boll weevil, *Anthonomus grandis*, while in Cuba only 45 miles away at the nearest points, is not yet in Haiti.

The Mediterranean fruit fly, *Ceratitis capitata* Wied, has never been recorded in Haiti and it has not been taken there so far as the records show.

Stephanoderes coffeae, the serious Brazilian coffee pest is not known to occur in Haiti.

A few specimens of the common Chinch bug were collected in a clump of a common grass in 1928, but the species is without economic importance.

References

Smith, Roger C. and H. D. Barker. Observations on the "Yellows" disease of beans and related plants in Haiti, Jour. Econ. Ent. 1930. 23: 842-847.

Smith, Rogers C. Bees and Beekeeping in sunny Haiti, Amer. Bee Jour. 1930. 70: 130-131, 184-185.

Wheeler, William M. and W. M. Mann. The Ants of Haiti, Bul. Amer. Mus. Nat. Hist., 1921, pp. 33.

Wolcott, George N. Entomologie d'Haiti, Service Technique, Port-au-Prince 1927, 440 pp., 133 figs.

WOLCOTT, GEORGE N. Increase of Insect Transmitted Plant Disease and Insect Damage Through Weed Destruction in Tropical Agriculture. Ecology, 1928, pp. 461–466.

WOLCOTT, GEORGE N. Haitian cotton and the Pink Boll Worm, Bul. Ent. Research. 1928. 18: 79-82.

WOLCOTT, GEORGE N. The May beetles of Haiti. Proc. Ent. Soc. Wash. 1928. 30:21-29.

WOLCOTT, GEORGE N. Notes on the Life History of *Exopthalmus quadrivittatus* Oliv., Proc. Ent. Soc. Wash., 1929, 31: 21.

WOODRING, WENDELL P., JOHN S. BROWN and WILBUR S. BURBANK, Geology of the Republic of Haiti, Bul. Dept. of Public Works, 1924, 631 pp.

SOME PHYSICAL PROPERTIES OF CERTAIN DORMANT OIL EMULSION-SULPHUR COMBINATIONS[1]

By M. D. FARRAR and M. A. SMITH

ABSTRACT

A recent development in a dormant tree spray is described. The spray combines a type of oil emulsion and Flotation sulphur in such a manner as to give an efficient combination spray for San Jose scale and peach leaf curl. The methods of mixing and the physical properties of the combination are discussed.

In some peach growing sections growers have become dissatisfied with liquid lime sulphur as a spray material for the control of San Jose scale and peach leaf curl. Their objections are based on its low efficiency of scale control and on the difficulty of handling due to its corrosive action. As a result, such combinations as Bordeaux oil emulsion, boiled lubricating oil emulsion with Bordeaux, and miscible oils combined with Bordeaux have come into wide use.

With the increasing use of wettable sulphurs, combinations of sulphur and oil have been developed for use in dormant sprays. During the course of several years' experiments at the Illinois Agricultural Experiment Station oil emulsions have been combined with sulphur for use as dormant sprays. Such combinations have been found to possess excellent insecticidal and fungicidal properties. They have been extremely easy to handle and have been used with entire safety on peaches, apples, plums, and small fruits. The present paper is a summary of studies made of the physical properties of some of the oil emulsion-sulphur combinations used as dormant sprays.

MATERIALS AND METHODS. In these studies formula L-21 was the chief oil emulsion used (Pl. 34, fig. 1.). L-21 is an experimental formula con-

[1]Joint paper.

Cooperative investigation between the Crop Protection Institute, the State Natural History Survey and the Department of Horticulture, University of Illinois, Urbana, Ill. This study has been made possible with funds supplied by the Standard Oil Company of Indiana and The Koppers Company of Pittsburgh, Pa.

taining an 83 viscosity (100°F.) lubricating oil emulsified with a gum. In addition to L-21, several types of commercial emulsions were used which contained various emulsifiers.

The sulphurs used were Flotation, ground elemental, sublimed, precipitated, and Ialine. In the experiments described in this paper the concentration of sulphur was made on an actual sulphur basis.

Flotation is a precipitated sulphur obtained in the manufactured gas industry from a process known as liquid purification. This process has been fully described by Sperr (7, 8) and Sauchelli (5).

When first obtained from the filter press it contains some soluble impurities and is known as unwashed Flotation sulphur. After most of these salts have been removed by washing it is known as washed Flotation sulphur. When washed Flotation sulphur is subjected to additional washing all of the soluble salts may be removed, leaving a pure sulphur paste. Such a sulphur has been designated in this paper as extra washed Flotation sulphur.

The ground elemental sulphur used was of a standard commercial grade.

The sublimed sulphur was prepared in the laboratory by the usual methods.

The precipitated sulphur used was obtained by treating lime sulphur solution with an acid.

The "Ialine" sulphur is a commercial product whose particles are in an extremely fine state of division.

After dilution of the different oil emulsion-sulphur combinations, microscopic mounts were prepared and measurements made. A microscopic examination was made of diluted samples of the oil emulsion used and measurements were made at frequent intervals. This was done to detect any possible change in the physical condition of the emulsion.

Experiments on the combination of oil emulsions with sulphur have indicated that a relation exists between the physical properties of the mixture and the method of combining the stock materials.

Such a combination contains an insoluble oil phase, water, water soluble emulsifier, and wettable sulphur. To bring such a combination into a stock of uniform stability, physical orientation of each material must take place. This adjustment conforms to theories of emulsification as expressed by Bancroft (1), Haskins (4), Finkle (3) in which the ingredients assume phases or interphases according to the surface tension between each ingredient. This combination is the oil enclosed type; the emulsifier assuming the interfacial position between the water and the oil. When the water, emulsifier, and sulphur are combined, before

mixing with the oil, and the mixture emulsified, the sulphur disperses into the water phase with only a very small quantity entering into the emulsifier interface. In such a combination the sulphur gradually settles to the bottom of the container in storage.

When a stock oil emulsion and sulphur are combined, an entirely different type of mixture results. In this method the sulphur is brought into intimate contact with the emulsifier which apparently attracts the sulphur. As a result, there is a union between the sulphur and the oil droplet that is not easily broken by dilution. When such a combination is diluted, many of the oil droplets carry particles of sulphur on their surfaces.

There is apparently a very important relation between the method of combining the oil emulsion and the sulphur, the relative size of the oil droplets, and the percentage of such oil droplets carrying sulphur. A typical set of such relations is expressed in Table 1.

TABLE 1. THE EFFECT ON THE PHYSICAL PROPERTIES OF AN OIL EMULSION-SULPHUR COMBINATION WHEN THE CONCENTRATION OF WATER IS VARIED

Parts by weight of			Average diameter in microns of oil droplets	Per cent of oil droplets carrying sulphur particles
Emulsion	Flotation sulphur	Water		
24	16	0.0	8.1	90.0
24	16	12.0	5.0	67.0
24	16	24.0	3.8	39.0
24	16	48.0	3.4	28.0
24	16	960.0	3.2	23.0
24	0	0	2.6	0.0

From Table 1 it is apparent that when the oil emulsion and sulphur are combined directly, without the addition of water, there is an increase in the size of the oil droplets, a high percentage of which carry sulphur. The size of the oil droplets and the percentage of droplets carrying sulphur decrease as more water is added to the combination.

It is believed that the addition of water suspends the sulphur in such a manner as to increase the distance between the sulphur particle and the emulsifier interface. This so weakens the bond of attraction between the sulphur particles and the emulsifier that there is little attachment between them.

Experiments were carried on to test the influence of various emulsifiers on oil-sulphur combinations. Typical commercial emulsions were used. The results of these tests appear in Table 2.

The following table shows a striking relationship between the type of emulsifier and its influence on the combination. Emulsions made with a gum emulsifier act similarly. The addition of Flotation sulphur to this type of emulsion results in the attachment of large numbers of sulphur

particles to the oil droplets. Oil droplets thus coated with sulphur tend to coalesce, increasing their size. Emulsions made with emulsifiers such as potassium fish oil soap, potassium caseinate, and petroleum soaps give a very low to negative attachment of sulphur particles to the oil and there is no change in the average size of the oil droplets.

TABLE 2. PHYSICAL CHARACTERS OF CERTAIN PROPRIETARY EMULSIONS WHEN COMBINED WITH FLOTATION SULPHUR

Type of emulsifier	Ave. diameter in microns of oil droplets	Ave. diameter in microns of oil droplets when combined with Flotation sulphur	Percentage of oil droplets carrying sulphur particles
Gum	8.6	18.2	97.0
Gum	6.5	13.0	80.0
Potassium fish oil soap	4.7	5.5	10.0
Potassium caseinate	5.0	3.7	8.0
Potassium caseinate	2.5	Not determined	Not determined
Pertoleum soap	1.0	Not determined	Not determined

A study was next made of the influence of sulphurs of different particle size on the size of oil droplets and the attachment of sulphur to them. These results appear in Table 3.

TABLE 3. THE INFLUENCE OF SULPHUR PARTICLE SIZE ON OIL-EMULSION SULPHUR COMBINATIONS

Type of sulphur	Particle size in microns	Influence on size of oil droplets	Percentage of oil droplets carrying sulphur particles
Ialine	1–3	None	15
Sublimed	1–3	None	1
Flotation	3–5	Large increase in size	95
Precipitated from lime sulphur by HCl	5–10	None	1
300 mesh ground sulphur	10–50	None	1
300 mesh ground sulphur and wetting agent	10–50	None	1

The results in Table 3 show that there is no direct correlation between the size of the sulphur particle, the size of the oil droplets, or the attachment of sulphur to them.

The fineness of the sulphur particles was not a factor in bringing about adherence of Flotation sulphur to the oil droplets. Ialine and sublimed sulphurs exhibited low adhering qualities although finer than Flotation sulphur.

It was believed that the small per cent of soluble electrolytic impurities contained in Flotation sulphur might exert some influence on the attachment of sulphur particles to the oil droplets and on the increase in size of the oil droplets. An experiment was carried on to test this view.

Flotation sulphur containing soluble electrolytic impurities in varying amounts was mixed with L-21 oil emulsion and each mixture examined microscopically. The results of these tests are given in Table 4.

TABLE 4. PHYSICAL CHANGES PRODUCED IN AN OIL EMULSION-FLOTATION SULPHUR COMBINATION FOLLOWING THE REMOVAL OF SOLUBLE IMPURITIES

No.	Stock emulsion	Per cent of electrolytic impurities	Ave. diameter in microns of oil droplets	Percentage of oil droplets carrying sulphur particles
1	L-21	0	3.0	None
2	L-21 and extra washed Flotation sulphur	Trace	4.7	11.0
3	L-21 and washed Flotation sulphur	.25–1.0	9.4	90.0
4	L-21 and unwashed Flotation sulphur	4–7	11.4	95.0

In Table 4, stock emulsions numbers 2, 3, and 4 show the role played by soluble electrolytic salts contained in Flotation sulphur; its relation to the size of oil droplets and the percentage of oil droplets carrying sulphur (Pl. 34, figs. 2, 3, 4).

The results of unpublished data of the writers show that the electrolytes as found in Flotation sulphur are of little fungicidal value. Apparently their value is physical, i.e. they impart to the Flotation sulphur the property of adherence to the oil droplets.

Experiments have shown that the amount of soluble salts contained in unwashed Flotation sulphur may cause injury to plant tissue when such sulphur is used at a concentration of over 2 pounds to 50 gallons of water (6). Although stock emulsion No. 4 exhibits slightly better physical properties than No. 3, the toxicity of this combination to plant tissue would make it unsafe if applied following the dormant period.

Three years' experiments of the writers have shown that stock emulsion No. 3 made with washed Flotation sulphur possesses high insecticidal and fungicidal properties and this combination has been applied with safety in both dormant and delayed dormant applications.

An experiment was next carried on to determine what effect larger quantities of sulphur would have on the physical properties of an oil emulsion-sulphur combination. The oil emulsion was mixed with the sulphur in varying quantities, water added, and microscopic examination made of each. The results of these tests appear in Table 5.

TABLE 5. THE EFFECT ON THE PHYSICAL PROPERTIES OF AN OIL EMULSION-FLOTATION SULPHUR COMBINATION WHEN THE CONCENTRATION OF SULPHUR IS VARIED

Pounds of sulphur to 50 gal	0	1	2	3	4	6	8	16
Average diameter in microns of oil droplets	3.5	9.4	9.2	8.1	9.8	10.6	14.8	19.8
Percentage of oil droplets carrying sulphur particles	0	8.0	40.0	80.0	85.0	90.0	90.0	90.0

As noted in Table 5, the percentage of oil droplets carrying sulphur particles varied greatly when the sulphur was used at the rate of one and two pounds of sulphur respectively to 50 gallons of water. The percentage of oil droplets carrying sulphur particles varied slightly when sulphur was used at 3 pounds and above. The average diameter of the oil droplets remained practically the same at concentrations of 1, 2, 3, 4, and 6 pounds of sulphur to 50 gallons. When the concentration of sulphur exceeded 6 pounds, there was an even greater increase in size of the oil droplets.

In 1928, 1929, and 1930, experiments showed that 4 to 6 pounds of Flotation sulphur when combined with L-21 gave satisfactory control of peach leaf curl and San Jose scale.

The efficiency of this combination is apparently correlated with its physical properties. In the field, a type of coverage is obtained whereby the distribution of oil and sulphur is uniform and in very intimate contact with the host. (Plate 35) After the emulsion breaks, there is a close association of oil and sulphur. This type of coverage furnishes a protection not obtainable by other dormant spray materials.

Conclusions

1. When L-21 oil emulsion and sulphur were combined directly the physical properties were superior to a combination in which excess water was added at the time of mixing.

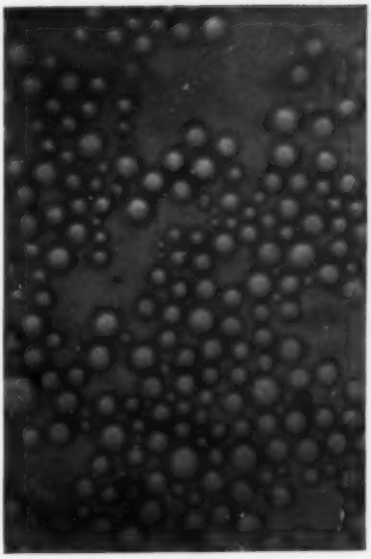
2. Oils emulsified with a gum in combination with sulphurs were superior physically to those emulsified with potassium fish oil soap, potassium caseinate, and petroleum soaps.

3. Sulphur particle size was shown to be a minor factor in the combinations of oil emulsion and sulphur used.

4. Flotation sulphur at various stages in its purification contains electrolytes in small quantities. These electrolytes were found to exert a very important influence when L-21 and Flotation sulphur were combined.

5. Laboratory experiments indicated that the most desirable physical properties of the combination were obtained when from 4 to 6 pounds of Flotation sulphur were combined with 1½ gallons of L-21 and diluted in 50 gallons of water.

6. Three years' field data showed that L-21, when used at 1½ gallons and Flotation sulphur (dry basis) at 5 pounds to 50 gallons of water, was a highly efficient combination for the control of San Jose scale and peach leaf curl.



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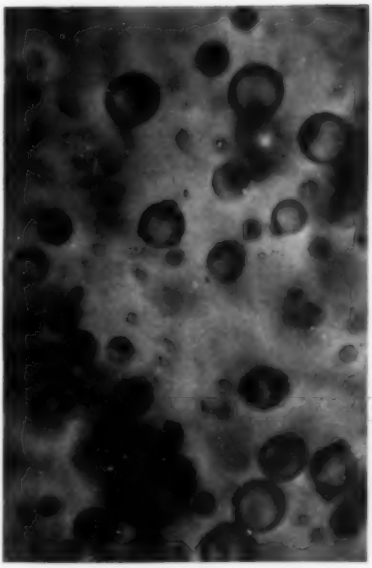

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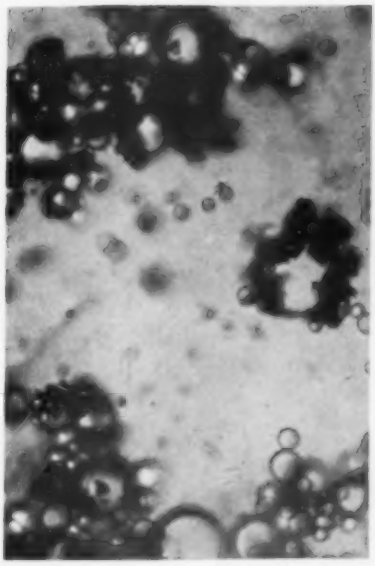


4

1, L-21 oil emulsion; *2*. L-21 oil emulsion combined with extra washed Flotation sulphur; *3*. L-21 oil emulsion combined with washed Flotation sulphur; *4*. L-21 oil emulsion combined with unwashed Flotation sulphur. Photomicrographs x 800.

a b c d

Photograph of peach twigs sprayed with (*a*) L-21 oil emulsion; (*b*) L-21 oil emulsion and extra washed Flotation sulphur; (*c*) L-21 oil emulsion and washed Flotation sulphur; (*d*) L-21 oil emulsion and unwashed Flotation sulphur (Natural size).

BIBLIOGRAPHY

1. BANCROFT, W. P. The theory of emulsification. Jour. Phys. Chem. 19: 275–309. 1915.
2. CUTRIGHT, C. R. Combination insecticide and fungicide sprays for dormant and delayed dormant spraying in Ohio. Bimonthly Bull. 14:42–44, Ohio Agr. Exp. Sta. 1929.
3. FINKLE, P.; DRAPER, H. D.; HILDEBRAND, J. H. The theory of emulsification. Jour. Amer. Chem. Soc. *45:* 2780–2788. 1923.
4. HASKINS, W. D.; DAVIS, E. C. H.; CLARK, G. L. Orientation of molecules in the surface of liquids, the energy relations of surfaces, solubility, adsorption, emulsification, molecular association, and the effect of acids and bases on interfacial tension. Jour. Amer. Chem. Soc. *39:* 541–596. 1917.
5. SAUCHELLI, V. A new by-product sulfur for agriculture. Chemical Markets 24:3–4. March, 1929.
6. SMITH, M. A. The control of certain fruit diseases with flotation sulphurs. Phytopathology 20: 535–553. 1930.
7. SPERR, F. W., JR. New methods of gas purification. Canadian Gas Association Proceedings. 1926.
8. ——— Gas purification in relation to coal sulfur. International Conference on Bituminous Coal. Vol. II, Nov. 1928.

DENSITIES OF MIXTURES OF AIR AND VARIOUS FUMIGANTS

By R. C. ROARK and O. A. NELSON, *Insecticide Division, Bureau of Chemistry and Soils, Washington, D. C.*

In order to judge the suitability of a compound for use as a fumigant, it is desirable to know certain of its properties. Among these are (1) toxicity to the pest to be destroyed, and (2) vapor pressure, from which an idea of the volatility can be obtained and the maximum quantity of material that can exist in vapor form in a definite volume can be calculated. These two factors have been considered in former publications.[1] There is another property which is of importance, inasmuch as it influences the distribution of the fumigant during application; i.e., the density of the vapor evolved by the fumigant. The present paper will consider this property of the compounds most frequently used.

It is a more or less common practice to speak of the vapor of a fumigant as being heavier or lighter than air, and when figures are given to illustrate the point, they are usually simply calculated from the molecu-

[1]Cotton and Roark, J. Econ. Ent. 20: 636–639, 1927; Ind. Eng. Chem. 20: 380–382, 1928; and 20: 805–806, 1928; Roark and Cotton, J. Econ. Ent. 21: 135–142, 1928; Ind. Eng. Chem. 20: 512–514, 1928; U. S. D. A. Tech. Bull. 162, March, 1930. Roark and Nelson, J. Econ. Ent. 22: 381–387, 1929. Nelson, Ind. Eng. Chem. 20: 1380–1382; and 1382–1384, 1928. Young and Nelson, Ind. Eng. Chem. 21: 321–322, 1929.

lar weight of the compound, and hence refer to standard conditions of 760 mm. of mercury pressure and 0°C. Such standard conditions are, of course, possible only for gaseous fumigants. A liquid or solid fumigant when used at a temperature below its boiling point evolves vapor which mixes with the air above and saturates it if conditions are favorable. This saturated air generally differs in density from air itself, and tends to rise or fall through the surrounding air as the case may be. This tendency to rise or fall of course varies as the density of the saturated air approaches or departs from that of pure air. Thus, the tendency of carbon disulfide vapor to fall in a fumigating chamber is not to be judged by the figure 2.62 which is its theoretical density under impossible "normal "conditions, but by the figure 1.76 which is the density (referred to air) of air saturated with carbon disulfide at 25°C.

It is obvious that in order to calculate the weight of a unit volume of any mixture of fumigant and air it is necessary only to add together the weight of air and the weight of fumigant contained in that volume.

A consideration of the law of partial pressures leads to the following formula for the case of two gases,

$$D_t^p = \frac{M}{V} = \frac{P-p}{P} D^1 + \frac{p}{P} D_2 \frac{273}{273+t}$$

in which D_1 and D_2 represent the theoretical densities of the two individual gases under "normal" conditions (and hence derivable from the molecular weights), D_t^p represents the density of the mixture under the actual conditions of pressure (P) and temperature (t° C.), and p represents the vapor pressure of the fumigant at t°.

Because most recommendations for fumigation quote the dosage in pounds per 1,000 cubic feet, and most fumigations are carried out at about 25° C. (77° F.), these conditions have been adopted as a basis for the calculations reported here. For these conditions, the formula just given reduces to

$$\text{Pounds per 1,000 cubic feet} = 73.95 + \frac{p(M-29.0)}{298}$$

in which p is the number of mm. of mercury pressure and M is the molecular weight of fumigant.

Table 1 gives the density thus calculated and in addition the specific gravity of each mixture in relation to air at 25° C. and 760 mm. pressure.

It will be observed that of the 28 compounds discussed only four give mixtures with air which have a density less than that of pure air, and of these four hydrocyanic acid is the only one commonly used as an insecticidal fumigant. (Statements to the effect that hydrocyanic acid

TABLE 1. DENSITIES AND SPECIFIC GRAVITIES OF SATURATED MIXTURES OF AIR AND FUMIGANTS

Compound	Formula	Mol. Wt.*	Vap. pres. mm. Hg. at 25°C.	Density (mass of 1,000 cu. ft. satd. mixt. at 760 mm. Hg. and 25°C. (77° F.)	Sp. gravity air = 1 at (25° C. and 760 mm.)
			Mm. Hg.	*Pounds*	
Air			760	73.95	1.0000
Ammonia	NH_3	17.03	760	43.40	0.5868
Arsine	AsH_3	77.98	760	199.20	2.6937
sec.-Butyl formate	$HCO_2C_4H_9$	102.08	48.1	85.77	1.1598
Camphor	$C_{10}H_{16}O$	152.13	0.19	74.03	1.0011
Carbon dioxide	CO_2	44.00	760	112.20	1.5173
Carbon disulfide	CS_2	76.14	357.1	130.44	1.7638
Carbon monoxide	CO	28.00	760	71.40	.9655
Carbon tetrachloride	CCl_4	153.83	114.5	121.91	1.6486
Chloroform	$CHCl_3$	119.37	199.1	134.38	1.8172
Chloropicrin	CCl_3NO_2	164.38	23.8	84.73	1.1458
Cyanogen chloride	CNCl	61.47	760	156.96	2.1225
p-Dichlorobenzene	$C_6H_4Cl_2$	146.95	1.0	74.35	1.0054
Ethyl acetate	$CH_3CO_2C_2H_5$	88.06	92	92.20	1.2468
Ethylene	C_2H_4	28.03	760	71.48	.9665
Ethylene dichloride	$C_2H_4Cl_2$	98.94	79.6	92.60	1.2522
Ethylene oxide	C_2H_4O	44.03	760	112.28	1.5183
Ethyl formate	$HCO_2C_2H_5$	74.05	255.0	112.50	1.5212
Formaldehyde	HCHO	30.02	760	76.55	1.0351
Hydrocyanic acid	HCN	27.02	738.8	68.90	.9317
Isobutyl formate	$HCO_2C_4H_9$	102.08	43.5	84.51	1.1428
Isopropyl formate	$HCO_2C_3H_7$	88.06	138.5	101.37	1.3708
Methyl chloroacetate	$CH_2ClCO_2CH_3$	108.50	9.0	76.37	1.0327
Methyl formate	HCO_2CH_3	60.03	614.0	137.88	1.8645
Naphthalene	$C_{10}H_8$	128.06	0.10	73.98	1.0004
Nicotine	$C_{10}H_{14}N_2$	162.13	0.12	74.01	1.0008
n-Propyl formate	$HCO_2C_3H_7$	88.06	85.0	90.79	1.2277
Sulfur dioxide	SO_2	64.06	760	163.36	2.2091
Tetrachloroethane	$C_2H_2Cl_4$	167.84	6.4	76.93	1.0403

*Molecular weights calculated according to 1928 revision of atomic weights. (J. Am. Chem. Soc. 50, 615, 1928).

gas is heavier than air have been seen in entomological literature, but are obviously erroneous.) From this it may be seen that in the absence of air-mixing devices, it is generally preferable to apply a fumigant at the top of the chamber, so that the heavier vapors will fall and thereby be more evenly distributed.

THE CALIBRATION OF FLOW METERS FOR THE MEASUREMENT OF INSECTICIDE GASES

By LYMAN C. CRAIG, *Department of Chemistry* and C. H. RICHARDSON, *Department of Zoology and Entomology, Iowa State College, Ames, Iowa*

In determining the relative toxicity to insects of a number of nitrogen bases in the gaseous state, it became necessary to have several flow meters accurately calibrated for different rates of flow. Flow meters were used extensively during the World War for research on poisonous gases and since then have been widely employed for chemical investigations on gases. In the chemical literature[1] theoretical discussions concerning the type of flow meter best suited for each purpose, the approximate size and length of a capillary for a certain rate of flow and the limits of accuracy are given. However, on looking over this work it seemed that more specific directions for the calibration of flow meters would be well worth placing in the entomological literature.

The following discussion concerns the resistance-tube flow meter which is shown in figure 88, A. It consists essentially of a horizontal tube of suitable bore with a manometer tube attached and suspended vertically from it. Between the arms of the manometer tube at B, the horizontal tube is constricted permitting a rubber stopper pierced by a short length of capillary tubing to be snugly fitted. This capillary offers resistance to the flow of air through the horizontal tube causing a displacement of liquid in the manometer tube, the displacement being proportional to the rate of air flow. By using capillaries of various diameters widely different rates of flow may be obtained.

In calibrating the flow meter, the volume of gas passed per unit time is accurately determined for a certain difference in level on the manometer scale. The volume for rates of flow over twenty liters per hour is best measured by means of a standard clock meter, whereas rates under twenty liters can most accurately be determined by measuring the volume of water drawn from an aspirator bottle when the rate of flow is held constant. It was more difficult to maintain a constant rate of flow over a period of time than was first expected, but the set up shown in Figure 88 gave very satisfactory results. A similar apparatus has been in use for some time in the laboratory of Dr. R. M. Hixon, in the Department of Chemistry, Iowa State College.

The flow meter A should be well cleaned with cleaning solution so that drops of water will not adhere to the walls of the manometer arm and

[1]Benton, A. F. J. Ind. & Eng. Chem., 11, 623 (1919), Fuwa, T. and G. A. Shattuck, Ibid., 15, 230 (1923.)

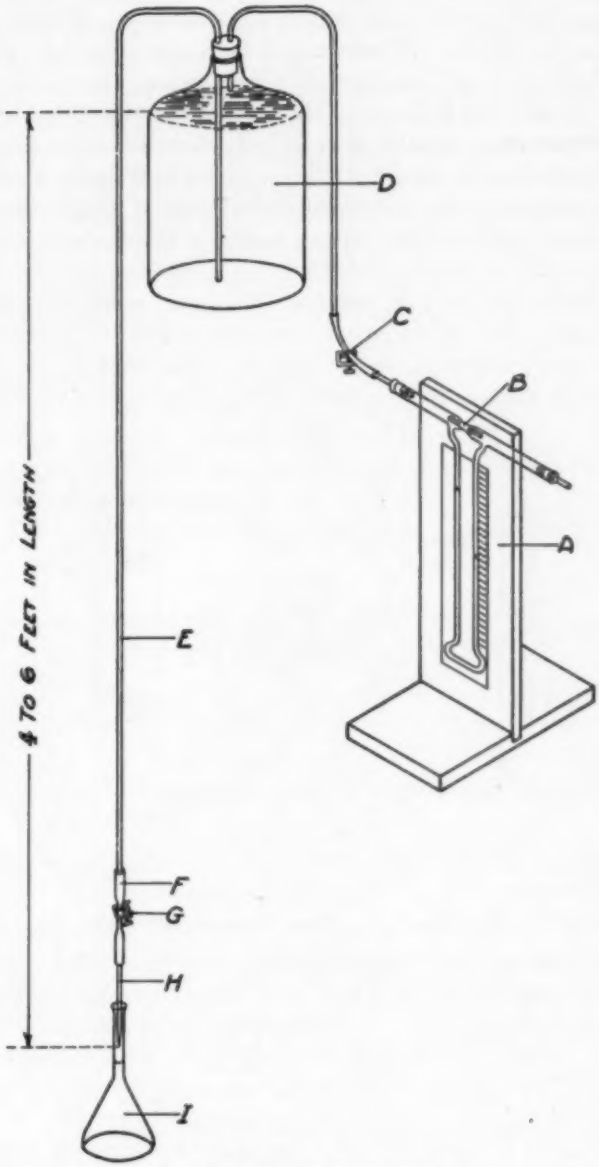


FIG. 88.—Resistance-tube flow meter.

thus give incorrect results. C and G are Hoffman clamps. D is a bottle of twenty to thirty liters capacity. The tubing E may be of rubber or glass. F is a piece of rubber tubing of small bore. I is a volumetric flask of convenient size. All connections must be air tight. This is very easily tested by filling D and E with water then opening G and closing C. In a few minutes water should cease to run from H. The opening at H, which consists of a piece of glass tubing, should be so small (approximately 1/8 inch in diameter) that the column of water will remain in E. The few minutes required for the establishment of equilibrium is caused by the air space in D which acts as a cushion. When the system is found to be air tight, C is opened and G is closed sufficiently to give the proper reading on the scale of A. It requires at least ten minutes for the reading on the scale of the flow meter to become constant. The time necessary to fill the volumetric flask I is taken with a stop watch, and is recorded as is also the reading on the scale of A. The volume per unit time is

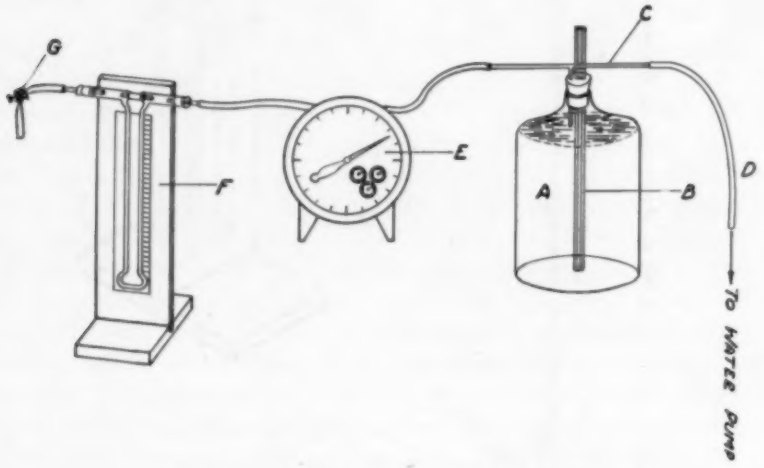


FIG. 89.—Set up for calibrating flow meters.

plotted against the flow meter reading. For most work on toxic gases the flow is given in liters per hour and the manometer reading in centimeters. Sufficient points are obtained to assure one of the correctness of the curve. The curve is almost a straight line when the orifice is small, but shows more curvature toward the lower end, as the size of the orifice increases. For an explanation of this see Benton (1).

When the set up is first used constant rates of flow are difficult to obtain. This must be due to the change of physical properties or acclimation of the walls of the rubber tubing directly under the clamp G.

This variability is less noticeable in a tube of small bore than in one of large bore. A negligible error is introduced if an average manometer reading is used provided the variation is not too great and equilibrium has been reached in D.

A convenient set up for calibrating flow meters with rates of flow greater than 20 liters per hour is shown in Figure 89. A is a bottle of approximately 20 liters capacity. An ordinary water pump is attached to the rubber hose D. E is a clock meter. The bottle A, should contain sufficient water so that its depth is somewhat greater than the height of the manometer arm of the flow meter F. When a strong flow of water is passing through the water pump the rate of bubbling from B will be faster than when a slow one is passing. If only one tube is used at B the rate of bubbling effects the pressure in the system. Several tubes help to overcome this effect. The rate of flow desired in the flow meter is regulated by means of the Hoffman clamp G.

Flow meters calibrated by either of the two methods outlined should not be in error over 1% if the proper range of the scale is used. For measuring different gases in biological work the flow meter is especially useful as it gives directly the rate of flow at any instant of time.

A SOIL-WASHING DEVICE FOR USE IN WIREWORM INVESTIGATIONS[1]

By F. H. SHIRCK, *Assistant Entomologist, Truck-Crop Insect Investigations, U. S. Bureau of Entomology*

ABSTRACT

An apparatus for separating eggs and young larvae of wireworms from field samples of soil by washing is described.

In connection with field studies on the egg and early larval stages of wireworms, some form of soil-washing apparatus was found necessary. The washer herein described was used during the past season, and proved satisfactory. This washer was patterned somewhat after the one described by Morris (*1*), but differs considerably in design, especially in being of somewhat simpler construction.

This washing apparatus consists of a rack containing a series of sieves, a hose equipped with an adjustable nozzle, and a small, funnel-shaped sieve with a removable bottom which is used in collecting the residues after washing is completed. Figure 90 gives the dimensions of the rack and shows details of its construction. The material used

[1]Approved for publication by Secretary of Agriculture, May 24, 1930.

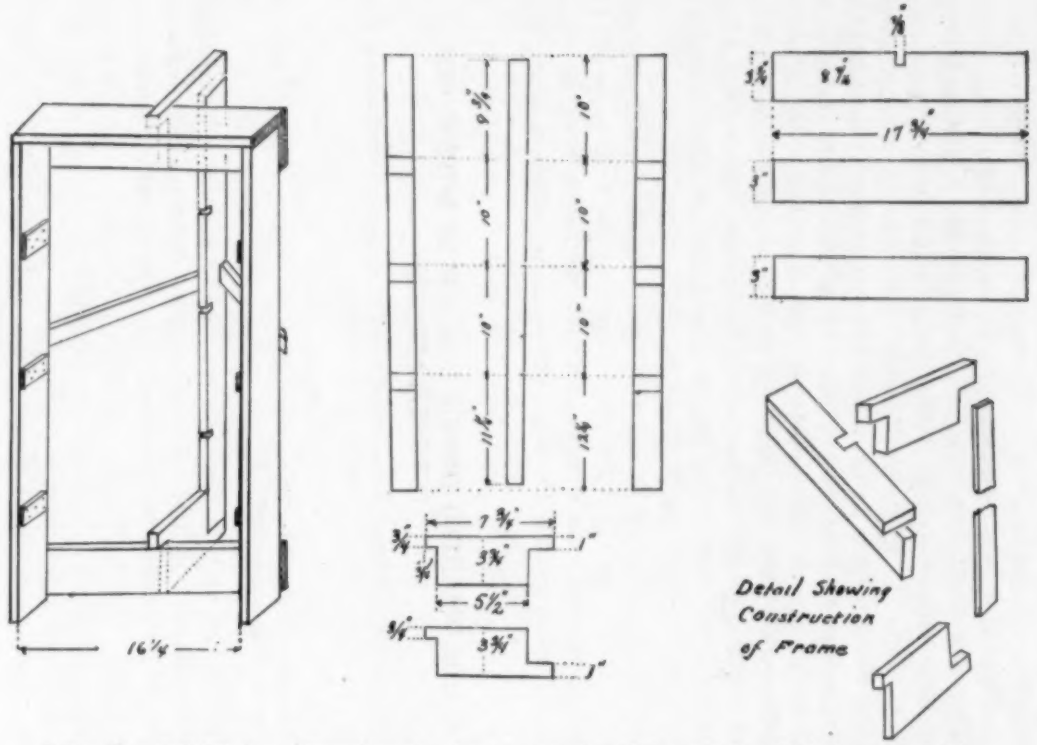
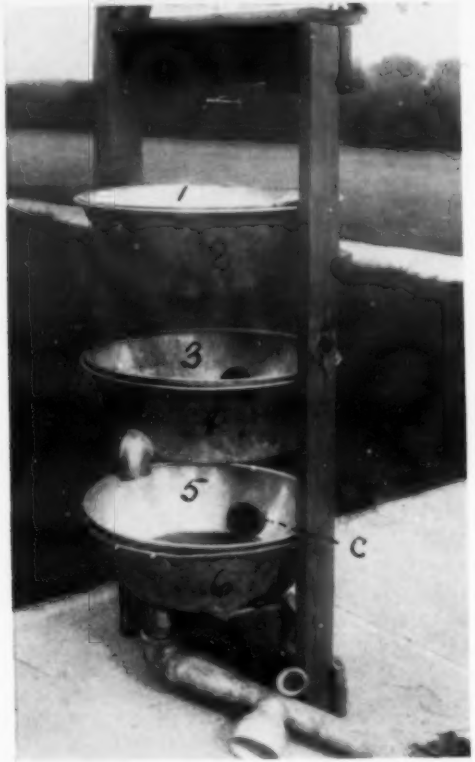


Fig. 90.—Soil Washer. Drawings showing construction of the rack in which sieves are held.



1. Assembled Washer. The small funnel for collecting residue is shown leaning against the drain pipe.

2. Showing method of removing residue from sieve.

was pine, three-fourths of an inch in thickness. Plate 36, 2 shows the assembled washer. The sieves were made by cutting the bottoms out of tin dishpans and soldering on brass screen cloth. The screen of the top sieve has ten meshes to the inch. Below this follow successively the 16-mesh, 30-mesh, 40-mesh, and 50-mesh sieves. Practically all of the eggs of the wireworms were retained in the 40-mesh screen. The 50-mesh sieve is required only for newly-hatched wireworms, some of which pass through the 40-mesh screen. The lowest pan has a solid bottom and serves to catch the wash water, which is led away through the drain.

The pans used in making the sieves were of two sizes. Pans numbered 2, 4, and 6 are each 4 inches deep and measure 16¼ inches (including ¾-inch flange) across the top. These pans fit into the three sets of supports on the frame and are held from tipping by inserting the flanges into the notches in the rear leg of the frame. Pans numbered 1, 3, and 5 are of smaller size, measuring 15½ inches in extreme width across the top and 2½ inches in depth. These smaller pans fit down inside the larger ones as shown in Plate 36, 1. When in position, the distance between the bottoms of the upper and lower pans in each pair is 1½ inches. To facilitate draining the pans short spouts or collars of nickel-plated brass 2 inches in diameter were soldered in openings near the bottom edge of pans 3, 4, and 5. Corks are used to stop these openings. It would be possible to use pans of uniform size by providing a support for each pan, and the spouts or collars could be of any metal that could be soldered to the tin. A funnel-shaped sieve with interchangeable screen bottoms is used to collect the residue from the pans.

The sample of soil to be washed is placed in the top sieve and the water is sprayed on it. Care must be taken not to splash the soil out of the sieves by use of too much pressure. The eggs and larvae of most wireworms, including two species of Limonius studied, will withstand without injury as much washing as is required to sieve the soil. The soil is carried through the two top screens without difficulty, but the finer meshes of the lower screens may become clogged. When a sieve clogs, draining can be started again by spraying water upward against the bottom. When the washing is completed, the material to be examined is collected by removing the drain cork (one is shown at "C," Plate 36, 1) and flushing the residue out through the opening into the funnel sieve as is shown in Plate 36, 2. When collecting the residue from pans 3 and 4 a 40-mesh screen is used in the bottom of the funnel and when collections are made from pan 5 a 50-mesh bottom is used. The funnel is swung back and forth a few times to shake out as much water as possible, after which the sieve bottom is removed and the material emptied from it

into a 2-ounce salve box for later examination. The residue is collected from pans 3, 4, and 5 through the opening fitted with the short spout. When the washer is in use these openings are tightly corked from the inside. No spouts are required on pans 1 and 2 as the coarse material collected in them can be readily examined and discarded at the time of washing. The spout on the bottom pan connects with a drain pipe which carries away the water.

This washer can be used out of doors wherever there is a hydrant to which the hose may be attached. It should be sheltered from high wind, as water may otherwise be blown out during passage from one screen to another. During calm weather, or with only a light breeze, water passes from one sieve to the other without splashing out.

One hundred and forty-four cubic inches, or about 8 pounds, of soil can be washed at one time. About six of such samples can be washed in an hour.

LITERATURE CITED

1. MORRIS, HUBERT M. A Method of Separating Insects and other Arthropods from Soil. Bull. Ent. Research, Vol. XIII, pt. 2, p. 197–200. London. 1928.

AN HUMIDITY APPARATUS[1]

By R. W. BURRELL, *Assistant Entomologist, Bureau of Entomology, United States Department of Agriculture*

ABSTRACT

A relatively simple and inexpensive apparatus is described which may be used in the production of desired high humidity in rearing rooms and incubator cellars.

It is generally recognized that the maintenance of a proper moisture content in the air is necessary for the most successful rearing of insects. Most of the parasitic insects handled at the Japanese Beetle Laboratory are soil-inhabiting forms, and require a high relative humidity. The apparatus to be described was devised to produce and maintain a relative humidity of 92 to 94 per cent in an incubator cellar used for rearing *Tiphia* cocoons. However, it is adaptable for use in nearly any situation requiring the production of humidity on a large scale. The principle utilized is the blowing of air over wet screens. The air is furnished by a fan which also, through a series of reduction gears, furnishes the power to rotate the screens in a pan of water. Small cups attached to the screens aid in keeping them thoroughly wet. This method of producing humidity provides humidified air which is the result of contact with wet

[1]Contribution No. 80. Research Laboratories, Moorestown, New Jersey.

surfaces and which does not contain fine floating droplets. The writer is greatly indebted to Mr. J. K. Holloway, whose valuable suggestions aided materially in the perfection of the apparatus.

The pan which holds the water is about 2 inches deep and is made of heavy metal provided with a flange to ensure maximum rigidity. The screens are disc shaped, 10 inches in diameter, and are cut from heavy galvanized screening, four meshes to the inch. They offer a large amount of evaporative surface with a minimum of resistance to the free passage of air through and around them. The number of screens may be variable but 16 were used in the apparatus described. The screens are mounted on a threaded brass shaft one-half an inch in diameter, are separated by small blocks of wood half an inch thick, and are firmly clamped in place by means of a nut at either end. The shaft rotates in ball bearings to provide a minimum of friction and reduce the strain on the driving motor. The small bearings used in Ford generators are an ideal size, and are mounted in supports fastened to the pan (Pl. 38, figs. 3 and 4). The shaft is placed so that there is a clearance of about a quarter of an inch between the screens and the bottom of the pan. Small metal cups half an inch wide, half an inch deep, and an inch long are soldered between each pair of screens (Pl. 38, Fig. 4). Each cup has the side wall nearest the shaft bent inward at the center in a broad "V" shape, so that the water is distributed equally over the two surfaces. It is also placed so that most of the water is released when the cup reaches the top of its circuit.

The motive power for the humidifier is a 12-inch oscillating type fan. The fan is reversed so that the blades push the air over the motor instead of away from it. This was accomplished by interchanging the end bearings, which reversed the rotor, end for end, within the field coils. The rotor and field coils are thrown out of alignment longitudinally, but the field coils can be pulled over into the proper position within the frame of the motor by means of the screws that hold the parts of the frame and the field coils together. This process reverses the direction of rotation of the blades.

The oscillating mechanism at the rear end of the fan is used to transmit the power to the shaft bearing the screens. Within the box containing the oscillating mechanism is a reduction series consisting of two spiral worms and two pinion gears. The last gear in the train has a speed of four or five revolutions per minute when the fan is running at high speed. It is keyed onto a shaft which goes through the gear box vertically, and it may be lifted out after removing the top of the gear box. This gear, after being removed from the fan, is fastened by a thin nut to the end of

the shaft bearing the screens. A hole is cut in the back end of the gear box just large enough to accommodate the shaft. It will be seen that the gear is thus utilized on the same worm, and at the same speed as when in use for its original purpose, and the only change that has been made is in its plane of rotation. When the pan is mounted on its stand it is adjusted horizontally and vertically so that the gear meshes with the worm without putting any weight on it.

The housings for the screens and the fan are made of galvanized sheet iron. The housing for the screens is fastened to the pan by means of bolts. It is of such diameter that there is approximately half an inch clearance when the screens are rotating. This allows enough air to pass so that little back pressure is built up, and yet forces most of the air to pass over the screens. The housing for the fan is made to fit exactly into the other housing. The two are joined and held together by means of sheet metal screws; this fastens them rigidly, though they can be readily detached. It is designed to allow the fan blades a clearance of a quarter of an inch. This small clearance is to decrease the angle of the housing that results from the attached end being 1½ inches smaller than the free end. This minimum angle is desired to reduce deflected air currents. The fan and the stand holding the pan are fastened to a common base to keep them in alignment. The water is supplied to the pan from a 5 gallon bottle by means of a siphon feed. The height of the water in the pan is adjusted so that the small metal cups are completely submerged when at their lowest point. This adjustment is kept constant by using a burette funnel as an air valve (Pl. 38, fig. 4).

If it becomes necessary to increase the rate of water evaporation a small air heater may be placed in front of the fan, or an immersion type water heater may be placed in the pan.

The humidifier as described has been tested over a period of several months under various conditions. It was originally built to maintain humidity in a cellar incubator 7 feet by 7 feet by 12 feet. This room is insulated by 4 inches of waterproofed cork and plaster, and is provided with refrigeration coils. It is possible to maintain constantly a relative humidity of 94 to 95 per cent at temperatures ranging from 45° to 48°F. by running the fan at low speed. A humidity of 98 per cent was attained by running the fan at high speed and putting a small air heater in front of it. In this type of room, where humidity leakage is low, the water bottle needs refilling only once a week.

It was found possible to maintain a humidity of over 80 per cent at temperatures ranging from 60° to 70°F. in a steam-heated insectary. The walls and ceiling of the room were of plaster board. It was 13 feet

1

2 Humidity apparatus.

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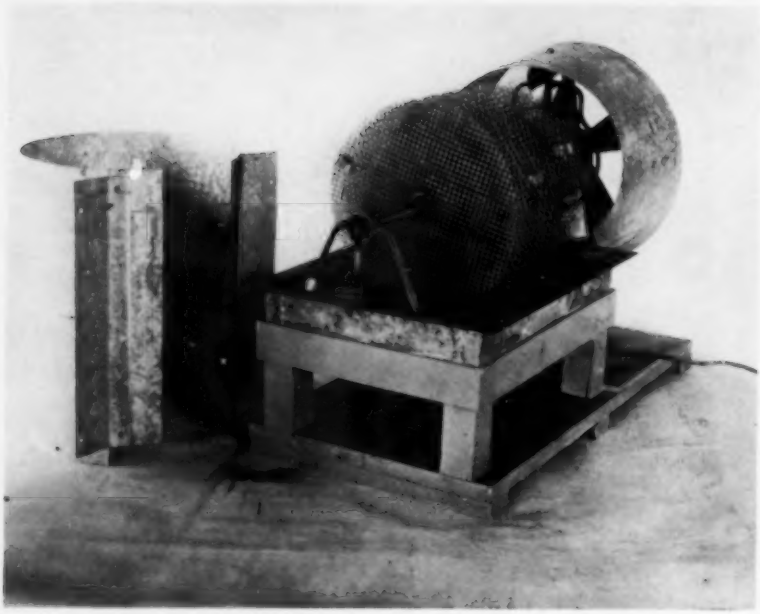

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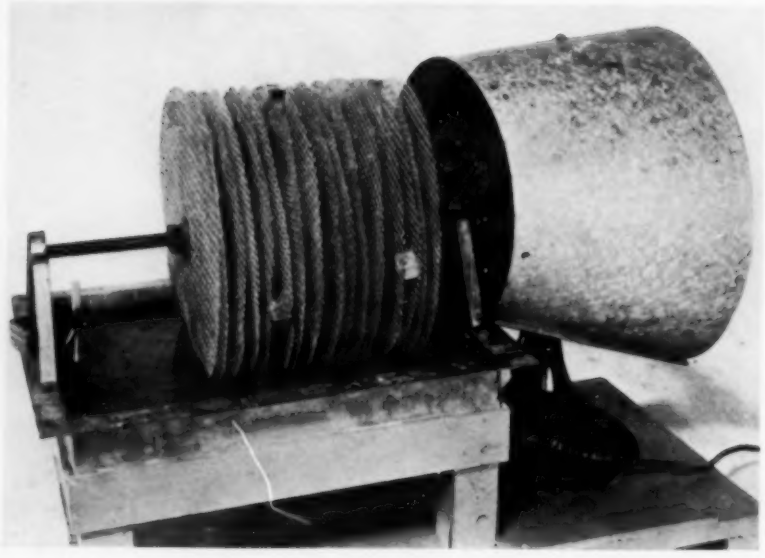


4 Humidity apparatus.

square and 8 feet high. No effort was made to record the maximum humidity that could be obtained under these conditions.

Another test was conducted in an unheated insectary 8 feet wide by 8 feet high by 24 feet long. During the test a window 3 feet by 6 feet located at one end of the room was open to the outside. The humidifier was placed at the end of the room next the window, and the recording instruments were situated at the other end. It was possible to maintain the relative humidity over 70 per cent, and ranging from 70 to 90 per cent except during windy periods, when the humidity fell to about 60 per cent.

Probably the first part to wear out in the humidifier would be the fan. With this in view the apparatus was assembled in two units so that the fan can be readily replaced. There is very little pulling load on the fan when the bearings of the screen shaft are in proper alignment, and at the end of over a month of continuous running the motor has not heated any more than one running the same length of time without the extra load. The life of a fan running constantly in an atmosphere of high humidity is about two years.

Such a humidifier as the one described can be assembled for $30 or $40. It may be adapted to many uses and various conditions. It has a possibility of being adjusted to meet varying demands by changing the size or number of the screens, by regulating the quantity of air passing over the screens, and by controlling the temperature of the water or the circulated air. When constant low humidities are required it may be impractical to vary the adjustments, and in such a case it would probably be better to use a humidistat in the fan circuit.

A MODERN GNAT TRAP

By E. O. Essig, *University of California*

For many years the Clear Lake gnat, *Chaoborus lacustris* Freeborn, has been a very great nuisance to the residents and vacationists along the shores of Clear Lake, a large body of fresh water in Lake County, California. In fact during the summer months the adult insects are so abundant and troublesome as to make the otherwise delightful evenings most disagreeable. This insect breeds in the waters of the lake in unbelievable numbers. The larvae, commonly known as phantoms because of their perfect transparency, live on the bottom during the day and come to the surface in the evenings and nights, where they feed on the plankton, and, when full grown, emerge as gnats. The gnats

swarm along the shores of the lake and collect in the tules, brush, buildings, and camps. They are attracted to lights and regularly collect about them wherever they are located near the shore. Camps, pee-wee golf courses, gasoline service stations, and residences *are fairly smothered by them!* The gnats do not bite, but inadvertently fly in the eyes, nose, ears, and mouth of those who happen to be near the lights. They also rest on the fruit trees during the day and swarm over the orchardists, especially at harvest time. The investigations of R. W. Burgess in 1928, resulted in the invention of a light trap,[1] a modification of which is now successfully used for the control of this obnoxious pest. This light trap is so simple and efficient that a description of it may assist others in solving similar problems elsewhere. The accompanying photographs, taken August 12, 1930, at the height of the gnat season, tell the story better than words. The three main points in the trap are: a light to attract the gnats, a small electric suction fan to remove them from the light, and a thin cheese-cloth bag to capture and hold the catch. The trap described is known as the Akins gnat trap and is manufactured by a local concern at Lakeport, the center of the gnat-infested district. The trap is made of thin sheet iron and is 24 inches in height, without the bag, and 15 inches in diameter. It is equipped with a 100 watt electric light bulb, with a reflector above and an electric suction fan below. The bag is of thin material to permit the ready escape of the air driven into it to carry the gnats and is 36 inches long and considerably larger than the diameter of the trap. It is securely tied about the base of the trap, so as to hang below the fan.

The traps are painted various colors to suit the aesthetic tastes of the owners and cost $10.00 each. They are suspended in various places from 6 to 30 feet above the ground to meet the exigencies of the case.

[1]Herms, W. B., and Burgess, R. W., Electric trap for night flying insects, Electrical News, pp. 29–30, 3 figs. (June 1, 1928).

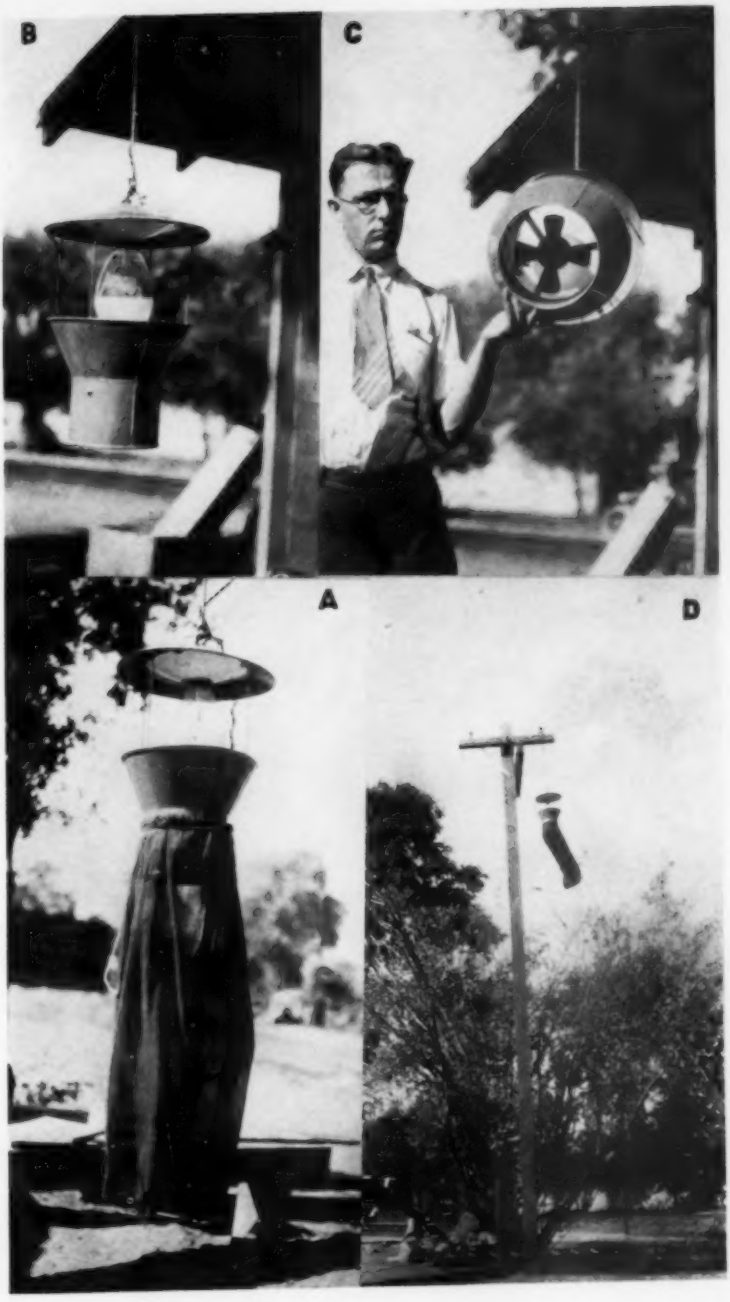
PLATE 39.—THE ATKINS GNAT TRAP

A.—The gnat trap suspended to show electrical connections, reflector, electric light bulb, and bag. The electric suction fan is located below the light where the bag is fastened.

B.—The gnat trap with the bag removed. The small bolts near the bottom hold the electric motor and fan in position.

C.—Bottom view of the gnat trap showing first the collar where the bag is attached, next the suction fan and small electric motor, and last the electric light bulb.

D.—The gnat trap suspended from an electric light pole. At night the action of the electric fan, inflates the bag.



The Akins Gnat Trap.

The trap illustrated in Plate 39, D, is one of two used to protect a pee-wee golf course. Traps around filling stations and camps are usually suspended from 6 to 12 feet high. It is an interesting sight to see the large number of these brightly colored traps hanging like Chinese lanterns along the shores of the lake and their bright lights at night add to the vacation spirit.

The effectiveness of the traps is illustrated by the fact that from 5 to 15 pounds of gnats may be taken by a single outfit in one evening—which represents a period of from two to three hours in the early evening when the gnats are on the wing. A pound of gnats is estimated to contain about two million individuals.

Great quantities of these gnats are now being used by the fish breeders in the county as a most attractive food for the young trout and other fish in the hatcheries.

Such a light trap may be useful also in collecting other night flying insects as water boatmen, mayflies, etc., or a similarly constructed trap, with a suitable bait or other attractants, instead of a light, may be employed to capture certain other types of insects.

PRELIMINARY REPORT ON A STUDY OF THE BIOLOGY OF *LIXOPHAGA DIATRAEAE* TNS.[1]

By L. C. SCARAMUZZA, *Assistant Entomologist,*[2] *Cuba Sugar Club Experiment Station, Central Baraguá, Cuba*

ABSTRACT

The Tachinid, *Lixophagae diatraeae* Tns., is the most important larval parasite of the sugar cane mothborer, *Diatraea saccharalis* Fabr., in Cuba. Parasitism reaches as high as 40% during spring and summer. The flies are larviparous and borer larvae can be inoculated by dissecting gravid females and placing maggots on the host. There are three larval stages, of which part of the first and second are attached to the trachea of the host while the third is always free within the host body. Six to seven days are required for the pre-larviposition period, 5.5 to 13 days in the larval stages, and 9 to 11 days in the pupal stage, making 20.5 to 32 days for the complete life cycle.

The Tachinid, *Lixophaga diatraeae* Townsend, known locally as the "Cuban Fly", is the most important and effective larval parasite of the

[1]Scientific Contributions No. 19, Tropical Plant Research Foundation. From the Cuba Sugar Club Experiment Station, Central Baraguá, Province of Camagüey, Cuba.

[2]The writer wishes to thank Messrs. H. K. Plank and U. C. Loftin, of the Department of Entomology, Cuba Sugar Club Experiment Station, for their many suggestions and assistance in carrying on the work, and the officials of Central Jaronú for their many courtesies.

sugar cane moth stalkborer, *Diatraea saccharalis* Fabr., in Cuba, Porto Rico, and some of the other West Indian Islands.

Surveys made by the Cuba Sugar Club Experiment Station (*1*)[3] have shown that this parasite is widely distributed throughout Cuba and that it is active the entire year, tho it is more abundant during the spring and summer when as high as 40% parasitism has been recorded. Altho it has been introduced and successfully established in Louisiana (*2*) and more recently reported as introduced into Mexico (*3*), Florida (*1* & *4*), Antigua, and Barbados for colonization, until the present all attempts at rearing have failed and its life history has remained unknown. This Station has recently undertaken a more intensive study of this insect to determine the possibility of increasing its usefulness locally by artificial propagation and distribution, and on account of its importance and interest to other entomologists working with the moth stalkborer of sugar cane, these preliminary notes are presented.

During the spring of 1930 the writer was assigned to this project and stationed at Central Jaronú, Camagüey province, where these investigations were made. The first attempts at rearing were made in various types of small cages but all of these proved unsuccessful. Larger cages measuring 14″ x 16″ x 36″ covered with wire screen and cheese cloth such as used for Tachinid mating and emergence at the Gipsy Moth Laboratory (*5*) were adopted. Windows made of old films cleaned of the emulsion were placed in each end to facilitate observation.

The mating cages were stacked in tiers in the laboratory where there was a free circulation of air and plenty of diffused light. The temperature ranged from about 78° to 90° F. with an average mean of around 85° F. Loaf sugar stuck to the sides of the cage with paraffin was found to be the best food. Plenty of moisture is an important factor in longevity and this was supplied by sponges set in small dishes of water and by spraying the cages several times daily with clean water by means of a small atomizer. The adults greedily drink the small drops of water from the sides and bottom of the cages. Under these conditions flies will live for as long as 40 days.

On June 25, 1930, 4 flies were confined in one of these cages with loaf sugar for food and more adults were added as they emerged from field collected puparia. On July 4, when there were 18 flies in the cage, 5 small *Diatraea* larvae which had been reared and known to be parasite free were introduced within pieces of split cane. These were left exposed to the flies for 3 days and removed from the cage. Two of these larvae

[3]Figures in parentheses refer to the "List of References" at the end of this report.

subsequently proved to be parasitized, the *Lixophaga* larvae emerging in 14 and 16 days after exposure.

Dissection of gravid females had shown that the embryonic larvae were matured while the eggs were still within the ovarian sac and that the maggots were hatched prior to or immediately after expulsion. Mr. H. K. Plank suggested and first successfully transferred young larvae secured by dissection to borer larvae with a small camel hair brush. As these entered and developed normally within the host, this method of inoculation was continued.

Mating has been observed twice, at 11 a. m. and 4:40 p. m., both times in strong diffused light but not in direct sunshine. The flies remained in copula from 3 to 3½ minutes. One of these females was dissected 55 hours after copulation was observed and the egg sac was distended with developing eggs. The other was left for 120 hours and the larvae within the eggs were found to be fully developed, but none had hatched. They were freed from the egg membrane with a dissecting needle and placed on borer larvae, and tho they were quite active, none succeeded in entering. These observations on the larval development indicate that about 6 days are required for the embryos to reach maturity.

Gravid females when dissected in saline solution were found to have 30 to 50 mature maggots in the lower ovarian sac, and several hundred immature eggs. Part of these larvae were found free of the eggs and were crawling about the sac while others hatched within a few hours. When these were removed with a camel hair brush and placed on the borer larvae, they readily penetrated the integument and entered in from ½ to 3 minutes. They select a tender spot for entrance, usually in a fold of the skin between the segments and near whatever part of the body they are placed upon. As soon as the borer larvae feel the parasites piercing their skin they become very agitated and try to dislodge them. Larvae secured by dissection have been kept alive in a saline solution for as long as 23 hours and were able to enter the host and develop normally.

While the parasites will enter the borer at any portion of the body where they are placed, the first stage larvae are later always found in the anterior half of the host with their caudal spiracles attached to the main trachea by means of a heavily chitinized tracheal funnel. Attachment is usually near the first or second abdominal spiracles, where the funnel remains permanently attached to the trachea after the larva has moulted and moved away.

The newly hatched *Lixophaga* larvae are about 1 mm. long, white in color, cylindrical in shape, and without bristles or spines. The mouth parts are well developed, terminating in two very black, slightly curved hooks. Attachment to the trachea takes place within 35 to 40 hours after entering the host and they remain in this position until after moulting once, or perhaps twice.

The second stage larvae are 2½–3 mm. long and in general appearance resemble the first stage. Some appear to remain attached to the trachea at the same place and by the same tracheal funnel as the first stage. Others appear to be free in the host body; so it is during this stage or at the time of the second moult that they become free.

The third stage larvae are 7 to 10 mm. long, creamy white in color, cylindrical, of uniform diameter, and with bluntly rounded ends. The body is covered with irregular rows of very fine bristles, mouth hooks very black and prominent, and more curved than in the other stages. Caudal spiracles are conspicuous, dark brown in color, reniform, with three spiracular openings. The third stage is always free within the host body and is without permanent respirational connections.

The length of the larval stages varies from 5 to 13 days with an average mean temperature of about 85° F. The average time for 8 males was 6.7 days; for 10 females, 7.1 days; and 40 flies of undetermined sex averaged 6.9 days. The length of the larval life depends somewhat on the size of the host, those emerging from smaller borers requiring more time. Normally *Diatraea* seem to be parasitized when they are from half to full grown (3rd to 5th instar), but *Lixophaga* have been reared from second instar borers. At other times emergence has been delayed until after pupation of the host. Sometimes two parasites and very rarely 3 develop within borers collected in the field and parasitized naturally. Under laboratory conditions when borers were inoculated with several parasites, usually all but one were killed during the second larval stage and in only one instance did two reach maturity. The borer larvae die from 6 to 48 hours before emergence of the parasite. Practically all of the body tissues are consumed in a small *Diatraea*, but with a large larva and only one parasite a considerable portion remains.

Upon reaching maturity the maggot tears an opening through the skin of the borer for emergence. This is usually in the last abdominal segment but emergence is sometimes through the anterior portion, just back of the cervical shield. The parasites may emerge either anterior or posterior end first and often reenter the borer remains if disturbed soon after emergence.

Pupation takes place within a few hours in summer but may be delayed 24 hours or more in winter. Under field conditions the puparia

are usually found in a dry place near the opening of the borer tunnel or between the leaf sheaths and stalk. In the laboratory the borer larvae are kept in tin salve boxes until after emergence and transformation of the parasites, and the puparia are then transferred to very fine, slightly moistened bagasse.

The puparia vary in size from 4.5 to 7.5 mm. (average about 6 mm.) depending upon the food, and are light brown in color when first formed, but change to dull black with age. They are slightly curved, of almost uniform diameter with well rounded ends, without spines and with the spiracles only slightly elevated. At summer temperature the pupal stage varies from 9 to 11 days but is almost invariably 10. With refrigeration this may be prolonged to 30 days or more, an important aid to introduction to other countries. Emergence takes place at any time of day or night. Two species of hyperparasites have been reared from *Lixophaga* puparia, but they are not common and are of little economic importance.

Very little is known as yet of the habits of this parasite under natural field conditions. Adult flies are found in the cane fields resting on the cane plants or feeding on pieces of cut cane, but have never been taken at other places or feeding on flowers. Judging from the structure of the mouth parts—the probosis is short and fleshy—their natural food is probably honey dew. This is always abundant on cane from the ever present mealy bugs and other Homopterons. Larviposition has not been observed but Mr. U. C. Loftin suggested placing newly born larvae on a stalk of cane near the entrance to a borer tunnel to observe their reactions. They wandered around a few moments until the borer hole was discovered, (probably attracted to it by the darkness) and immediately entered. When the holes were packed with frass, the larvae had no difficulty in working through. The canes were opened and the borers dissected 2–3 hours later, and the parasites were found inside the borer larvae, tho not yet attached to the tracheae. This is probably one of the ways by which the parasites reach the borer larvae under field conditions, as the borers are too well protected within the stalks for the maggots to be deposited directly upon their bodies.

Summary of Life History

The life history of *Lixophaga diatraeae* may be summarized as follows:

Pre-larviposition period	6–7 days
Larval stages within host	5.5–13 days
Pupal stage	9–11 days
Total	20.5–31 days

Breeding is continuous throughout the year under Cuban conditions, and there are probably 8 to 10 generations, corresponding closely with the generations of the host, *Diatraea saccharalis*.

List of References

1. Plank, H. K. 1929. Natural Enemies of the Sugar Cane Moth Stalkborer in Cuba. Ann. Ent. Soc. America, V. 22, No. 4, (December, 1929), pp. 621–640. (Tropical Plant Research Foundation, Scientific Contributions No. 15.)
2. Holloway, T. E., Haley, W. E., and Loftin, U. C. 1928. The Sugar-Cane Moth Borer in the United States. Tech. Bull. No. 41, U. S. Dept. of Agric., pp. 64–65.
3. Van Zwaluwenburg, R. H. 1923. Tachinids and Sarcophagids Established in Mexico. Jour. Econ. Ent. V. 16, No. 2, (April, 1923), p. 227.
4. Watson, J. R. 1928. [Report of the Entomologist], Fla. Exp. Sta. Report for 1928, p. 47 R.
5. Burgess, A. F., and Crossman, S. S. 1929. Imported Insect Enemies of the Gipsy Moth and the Brown-Tail Moth. Tech. Bull, No. 86, U. S. Dept. of Agric., pp. 18–20.

EPHESTIA ELUTELLA HUBNER, A NEW PEST OF CURED TOBACCO IN THE UNITED STATES

By E. A. Back and W. D. Reed, *Bureau of Entomology, U. S. Department of Agriculture.*

Abstract

On August 8, 1930, the moth *Ephestia elutella* Hübner was, for the first time in the United States, found infesting stored leaf tobacco in a small number of warehouses in Richmond, Va. While the insect is cosmopolitan in distribution and has been reported as feeding upon a wide range of agricultural products including tobacco, its presence in Richmond in destructive numbers has stirred the tobacco industry to prompt action looking toward effective control. Bibliography.

It is always interesting to record the appearance of a new enemy of any industry, especially an enemy that may become troublesome to an industry paying an annual federal tax of about 500 million dollars. Up to the current year, the tobacco beetle, *Lasioderma serricorne* F., has been recognized as the only serious pest of cured and manufactured tobaccos in the United States. During the past summer, rumors that a moth was damaging stored leaf tobacco in Richmond, Va., reached the Bureau and the junior writer, upon visiting the warehouses in question on August 8, found a heavy infestation of a Phycitid moth, later indentified by Mr. Carl Heinrich, of the Taxonomic Division of this Bureau, as *Ephestia elutella* Hb.

At various times throughout August and September, thousands of adult moths were to be seen during the day resting on the hogsheads and

cases of tobacco and upon screen doors and walls of the warehouses. Examination of the bright leaf tobacco stored in "hands" in the hogsheads left no doubt as to the capacity for damage possessed by the larvae. These latter were feeding upon the cured leaf, often leaving behind only the larger leaf ribs, and polluting the parts uneaten with web and frass. While the physical destruction of the leaf was very pronounced and widespread throughout about 8,000,000 cubic feet of storage space, scouting by the junior writer indicated that the infestation was confined to a rather small area of Richmond and did not extend to stocks in storage in other parts of the city or elsewhere. However, the destruction of leaf already caused, and the possibility of further spread, has given rise to grave concern in the tobacco industry and to a determination to limit the infestation to the area now infested and to exterminate it there if possible. Already the application of control measures has greatly reduced the numerical abundance of the pest.

While this is the first instance of infestation of cured tobacco by *Ephestia elutella* in the United States, the insect was recorded as a tobacco pest in Russia in 1915 (*9*) and in London during 1929. The United States Department of Commerce stated in September, 1930 (*18*), that the appearance of the worm, *Ephestia elutella*, in stocks held in bond at one of the London warehouses would, it was feared, materially depreciate the value of these stocks. The writers have been informed that the insect first appeared in London tobacco warehouses during the summer of 1929, in shipments of tobacco from Rhodesia, in sufficient numbers to cause the tobacco in hogsheads to depreciate in value. In Richmond, the brighter grades of cigarette tobacco were found most heavily infested and the feeding in hogsheads often extended as deep as 4 inches from the staves.

DISTRIBUTION AND FOOD. *Ephestia elutella* Hb. is a cosmopolitan storage pest although in America it seems to be present in negligible numbers except as above reported in tobacco, and, at times, in dried fruits in California as observed by M. E. Phillips and Perez Simmons. It has been reported from England, France, Germany, Italy, Russia, China, Africa (Cameroons, Gold Coast, Nigeria, Nyasaland, and Rhodesia), Australia, Ceylon, Java, Samoa, West Indies, Brazil, Costa Rica, Panama, Canada, and the United States (Calif., Ia., N. Y., Pa., N. J., and Va.)

The larvae have been reported as feeding upon cacao beans, cacao powder, chocolate, English walnuts, nuts, dried fruits, linseed and flaxseed meal, ships biscuits, dog biscuits, bread, cakes, coffee, red and cayenne pepper, dead insects, sugar, dried vegetables, rice, dried rhubarb roots, stored grain, seeds, cereals, pearl barley, peanuts, and tobacco.

Bibliography

1. Andres, A. 1920. Uber den Messingkäfer (Niptus hololeucus Feld.). (Zeitschr. Angew. Entom., vi, pp. 406–7.)
2. Curran, C. H., 1926. The identification and control of adult Lepidopterous insects Attacking Stored Products. (Scient. Agric., vi, no. ii, pp. 383–8, 6 figs. Ottawa.)
3. Dendy, A., and Elkington, H. D., 1919. On the phenomenon known as webbing in Stored Grain (Rep. Grain Pest (War) Cttee., Roy. Soc., London, no. 4.)
4. deOng, E. R., 1925. The Currant Moth on Peanuts. (Pan-Pacific Ent., ii, no. i, p. 46. San Francisco.)
5. Forbes, W. T. M. Lepidotera of New York and Neighboring States. Cornell Agr. Exp. Sta. Memoir No. 68, p. 623, June, 1923.
6. Gibson, Arthur, and Twinn, C. R. Household Insects and Their Control. Dominion of Canada Dept. Agr. Bul. No. 112, New Series, p. 29, June, 1929.
7. Granato, L., 1909. (Bol. Agric., San Paolo, 10, p. 283.)
8. Knapp, A. W., 1921. Insect Pests in the Cacao-store. (Bournville Works Publication Dept.)
9. Mokrzecki, S. A. & Bragina, A. T. Report of the Entomological Laboratory of the Experimental Station of Salgir for 1913–14. Simferopol, 1915, 9 pp. in Russian (R. A. E. Ser. A, Vol. 3, p. 613.)
10. Maskew, F., 1912. A serious Walnut Pest (*Ephestia elutella* Hb.). (Mthly. Bull., State Comm. Hort., Cal., 1, pp. 366–7.)
11. ———————— 1920. Quarantine Division, Report for April and May, 1920. (Mthly. Bull., Cal. State Dept. Agric., Sacramento, ix, no.7,pp.298–302.)
12. Mason C., 1915. Report of the Entomologist for the year ending 31st March, 1915. (Dept. Agric., Nyasaland Prot., Zomba.)
13. Meyrick, E., 1928. Revised Handbook of British Lepidotera. (London.)
14. Munro, J. W. and Thompson, W. S. Report on Insect Infestation of Stored Cacao. Empire Marketing Board, Report 24, H. M. Stationery Office, London, 1929.
15. Myers, J. G., 1928. Report on Insect Infestation of Dried Fruit. (E. M. B. 12, London, H. M. Stationery Office.)
16. Patterson, W. H., 1928. (Tropical Life, no. 281, pp. 25–6.)
17. Smits,——, 1914. Une invasion d'*Ephestia elutella* Hb. à la halle aux sucres de Lille. (Feuilles jeunes Natural., Paris, 44, pp. 73–5.)
18. United State Department of Commerce Bulletin 270, Sept. 9, 1930.
19. Vecchi, A.,—— Alcune notizie sull' *E. elutella* Hb. (Boll. Soc. Ent. Ital., lix, no. 4, pp. 50-52, 2 figs., 2 refs.)
20. Zacher, F., 1927. Sommergefahren für die Fabrikation und den Handel von Süsswaren. (Mitt. Ges. Vorratschutz, 3 no. 4.)
21. ————, 1927. Die Vorrats-Speicher-und Materialschädlinge und ihre Bekampfung., p. 250. (Berlin, Paul Parey.)

Scientific Notes

Oriental Fruit Moth Infestation in Georgia Peach Belt.—Owing to the absence of a host after midsummer, which causes a heavy mortality of oriental fruit moth larvae that would otherwise hibernate, this insect has never been of much economic importance in the central Georgia peach belt. However, there has been considerable speculation as to the extent of infestation in peaches harvested in that district, and at times growers have held the oriental fruit moth responsible for damage caused by the plum curculio. In order to obtain accurate data on the degree of infestation, all of the peaches from 50 record trees scattered throughout what was apparently the most heavily infested orchard in the vicinity of Fort Valley in 1930 were cut open to determine which contained oriental fruit moth larvae or had been damaged by the insect. No control measures whatever for the oriental fruit moth, had been practiced in this orchard, and the fruit was not harvested until after the larvae had ceased to work in peach twigs on account of their hardened condition. The 50 record trees produced 35,663 peaches, all of which were cut open, and of these only 452, or 1.3 per cent, were found to be infested by the oriental fruit moth.

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Benjamin Franklin on Entomology. In looking through "The Complete Works of Benjamin Franklin," edited by John Bigelow and published by Putnam in 1887, I noticed a letter from Franklin to Miss Mary Stevenson, written in London and dated June 11, 1760. As the letter is of interest to entomologists and has doubtless escaped the attention of many of them, it seems worth while to reproduce in an entomological journal that part of it which treats of the study of insects. Entomologists will be interested both in the record of Linnaeus's success in an economic investigation and in Franklin's counsel that entomology be studied in moderation. The quotation follows:

"Your observation on what you have lately read concerning insects is very just and solid. Superficial minds are apt to despise those who make that part of the creation their study, as mere triflers; but certainly the world has been much obliged to them. Under the care and management of man, the labors of the little silkworm afford employment and subsistence to thousands of families, and become an immense article of commerce. The bee, too, yields us its delicious honey, and its wax useful to a multitude of purposes. Another insect, it is said, produces the cochineal, from which we have our rich scarlet dye. The usefulness of the cantharides, or Spanish flies, in medicine, is known to all, and thousands owe their lives to that knowledge. By human industry and observation, other properties of other insects may possibly be hereafter discovered, and of equal utility. A thorough acquaintance with the nature of these little creatures may also enable mankind to prevent the increase of such as are noxious, or secure us against the mischiefs they occasion. These things doubtless your books make mention of; I can only add a particular late instance which I had from a Swedish gentleman of good credit. In the green timber, intended for ship-building at the King's yards in that country, a kind of worms were found, which every year became more numerous and more pernicious, so that the ships were greatly damaged before they came into use. The King sent Linnaeus, the great naturalist, from Stockholm, to inquire into the affair, and see if

the mischief was capable of any remedy. He found, on examination, that the worm was produced from a small egg, deposited in the little roughnesses on the surface of the wood, by a particular kind of fly or beetle; from which the worm, as soon as it was hatched, began to eat into the substance of wood, and after some time came out again a fly of the parent kind, and so the species increased. The season in which the fly laid its eggs, Linnaeus knew to be about a fortnight (I think) in the month of May, and at no other time in the year. He therefore advised, that, some days before that season, all the green timber should be thrown into the water, and kept under water till the season was over. Which being done by the King's order, the flies, missing their usual nests, could not increase; and the species was either destroyed or went elsewhere; and the wood was effectually preserved; for, after the first year, it became too dry and hard for their purpose.

"There is, however, a prudent moderation to be used in studies of this kind. The knowledge of nature may be ornamental, and it may be useful; but if, to attain an eminence in that, we neglect the knowledge and practice of essential duties, we deserve reprehension. For there is no rank in natural knowledge of equal dignity and importance with that of being a good parent, a good child, a good husband or wife, a good neighbour or friend, a good subject or citizen—that is, in short, a good Christian. Nicholas Gimcrack, therefore, who neglected the care of his family, to pursue butterflies, was a just object of ridicule, and we must give him up as fair game to the satirist."

T. E. HOLLOWAY, *U. S. Bureau of Entomology*

A Suggestion for the Automatic Collection of Sitotroga.—The successful utililization of the egg parasite *Trichogramma* depends on low production costs. At the present time the greatest advance toward this objective would be in reducing the time and labor now required in making the daily collections of the adult stage of its host. Recent investigations (see October number of the Journal) indicate that the use of the apparatus described in the following paragraphs would result in such a saving.

When the bins containing infested corn are stacked in position for production, the upper ends of the bins are covered with a single piece of closely woven cloth (4 feet square) hanging loosely from the cover of the top bin. This cloth is securely fastened at its four sides so that the moths cannot escape. The lower edge is attached to the outer side of a funnel having an opening 1 inch in width extending the width of the bins (4 feet) and on a level with and attached to the bottom bin. The lower or small end of the funnel is connected to the moth trap which is described on Page 838 of the October number of the Journal.

When in operation, a constant current of air enters at the top of the enclosure formed by the cloth and passes down between the bins through the mass of grain and out through apertures at the lowest part of each bin. The air pressure causes the cloth to bulge outward. The moths that collect in the cloth enclosure are collected at intervals in the trap by cutting the air pressure on and off rapidly several times, so as to shake the cloth, causing the moths to settle into the funnel and, at the same time, starting the suction motor on the trap.

STANLEY E. FLANDERS, *Citrus Experiment Station, Riverside, California*

A Predacious Mite on Alfalfa Thrips.—As far as the writer is aware, only one species of mite, *Hypoaspis* (*Laelaps*) *macropilis* Bks., has been reported from North America as preying on thrips. In connection with studies of alfalfa thrips (*Frankliniella occidentalis* Perg.), conducted in the vicinity of Greenwood, Utah, during 1928 and 1929, another species of mite was observed preying on this species of thrips to such an extent that it appeared to be an effective factor in reducing thrips population. Dr. H. E. Ewing had placed it as *Anystis agilis* Bks. (?) which is well-known to be predacious on various small insects. The mite was found in alfalfa flowers and to some extent running on the ground beneath the plants. Populations of the mite appear to vary directly as the thrips population, being higher during August and early September. At this time it was not uncommon to find two or three mites in several racemes. Where the mite was scarce, as was true in some localities, thrips populations were much higher than in localities where the mite (*Anystis agilis* Bks.) was established. In addition to this mite, another well-known thrips predator, *Orius* (*Triphelps*) *insidiosus* var. *tristicolor* White, which was identified by Dr. Drake, through the kindness of Mr. Harold Morrison, Bureau of Entomology, was found more abundantly than the mite and actively preying on the host throughout the season. A test of the relative effectiveness of these two species as predators was taken during September. These data are summarized below:

	Period of exposure Average	No. of cages	Total no. of thrips	Thrips per cage Average	No. of predators per cage	No. killed	Per cent	Number survived
Anystis agilis	25 hours	5	132	26.6	1	52	39.39	80
	49 "	4	99	24.7	1	20	20.20	79
Orius tristicolor	27 "	5	108	21.6	1	24	26.85	84
	49 "	4	93	23.2	1	31	33.33	62

K. SAKIMURA, *University of Hawaii, Honolulu, Hawaii*

An Additional Statement Concerning the Tank-mixture Method of Using Oil Spray.—The article on the tank-mixture method of using oil spray, appearing in the April number of the Journal of Economic Entomology and subsequently reprinted in Citrus Leaves and in Texas Citriculture, has occasioned a reaction which appears to warrant commenting upon at this time. It goes without saying that men in science and industry alike properly should take a conservative position with respect to pronouncements which suggest decided departures from generally accepted lines of thought and practice. Two principal factors are involved in the present case, the *a priori* position taken by entomologists and the horticultural industry that "home made" spray is taboo and the denunciation by the insecticide industry, through the medium of its salesmen and other personnel, of the idea that a method of using oil spray has been demonstrated which carries the possibility of eliminating to a large extent the use of prepared emulsions. The writer takes it for granted that the criticisms expressed are, for the most part, made in good faith. Much reference has been made to the fact that the enthusiasm over the so-called boiled lubricating oil emulsions and cold emulsions during the two or three years following the publication of formulae in 1922 and 1923 waned very quickly in the Pacific Northwest as a result of somewhat disastrous experiences. The implication is that the experience with "home made" oil spray has been such that to permit information to be printed which might encourage its use again is a dangerous and foolish thing for one to do. Future

research and experience will, of course, settle the questions that have been raised, but certain points concerning the oil spray work can be elucidated at this time with profit to all who may be interested.

(1) In the article referred to the writer specifically stated that the tank-mixture method probably has an important place in the spraying of citrus trees under the conditions of pest control existing in southern California and whether or not it is applicable to conditions met with in deciduous fruit districts, in dormant and summer spraying, remains to be determined by entomologists in such districts.

(2) It is true that oil sprays in the form of "mechanical mixtures" of oil and water, with and without the addition of soap or soap powders, were used more or less extensively prior to about the year 1910 and that this type of spray was completely abandoned in favor of prepared emulsions and miscible oils. The change might have been fully justified at the time it was made but with modern spray equipment and recent additions to our understanding of the functioning of oil spray mixtures, the return to the original method is distinctly in the line of progress; at least as pertains to spraying in the citrus districts in California.

(3) The disastrous experiences, if they were such, which may have resulted from the use of engine oil emulsions in the Pacific Northwest and elsewhere, were obviously due to an inadequate knowledge of certain facts which are well understood in the present case concerning spray oils and oil spray mixtures. The tank-mixture method is based on the fundamental tenet that in the use of an oil of given specifications as to viscosity, distillation range and sulfonation, the insecticidal efficiency and injurious effects, insofar as the spray mixture is concerned, depends entirely upon the amount of oil deposited during the process of spraying; and the amount of oil deposited can be governed by placing the spreader or emulsifying material directly in the water in the spray tank, adding the spray oil and maintaining a uniform mixture by means of the agitators. The stability of the emulsion or spray mixture and the size of the oil globules, factors which heretofore have been the focus of attention of oil spray investigators and oil spray manufacturers, become relatively negligible in importance.

(4) The tank-mixture cannot be regarded as a "home made" oil spray because the ingredients consist of a quantity of pure spray oil and a quantity of spreader, which are added separately to the water in the spray tank. No particular instructions must be followed concerning the order in which the ingredients are added or the time when they are placed in the tank. It is no more a "home made" spray than is a spray of lead arsenate, lime-sulfer, Bordeax mixture or nicotine sulfate to which a spreader is added.

(5) The dependability of the tank-mixture method hinges upon proper agitation and the proper kind and amount of emulsifier. The practicability of increasing the agitation in spray tanks so as to meet the requirements for the tank-mixture method has been established beyond any question of doubt in the case of modern, high-powered sprayers such as are used altogether in southern California. In other sections of the country where growers do their own spraying and the spray machines represent all vintages and are, in many cases, decidedly underpowered, the practicability of the tank-mixture method is questionable. No encouragement of its use should be made until the factors pertaining to spraying equipment have been carefully surveyed. It is the writer's firm belief, however, that in view of the difficulty experienced more or less generally with emulsions separating in containers before use and breaking when mixed with water in the spray tank, due to reactions between salts in the water and the emulsifying agent in the emulsions, all sprayers applying oil

spray should meet the agitation requirements which have been specified for the tank-mixture method.

(6) The term "emulsifier" loses its significance when used in connection with the tank-mixture method because no emulsion in the ordinary sense, is produced. The term "spreader", with the meaning that it generally conveys in insecticide literature, is perhaps a more suitable word because the object to be achieved is to govern the deposit of oil on the tree and that appears to be accomplished primarily by a phenomenon of wetting by the spray mixture. Since the article above referred to was published, considerable attention has been devoted to finding a suitable spreader for use with the tank-mixture. The shortcoming of caseinate spreaders and soaps is that very commonly their effectiveness is destroyed by reactions with the salts in the spray water. In spraying with lead arsenate such spreaders may be used in excessive amounts in order to offset the effect of reactions with the salts in the water, but this practice is not feasible in the case of oil sprays, especially those used on foliage, because the margin between safety and killing efficiency is very much narrower in the use of oil sprays than in the use of lead arsenate. The ideal spreader is one which is not subject to the reaction mentioned and it must also have the particular property of causing the spray mixture to wet in such a manner as will prevent the deposit of oil from becoming excessive. At the present time powdered blood albumen appears to be one of the most promising oil spray spreaders. It appears to have been used in a limited way in spray work in the past and a proprietary preparation in liquid form has been in use with a proprietary emulsion in California during the past four or five years.

A publication covering the oil spray investigation is in the course of preparation and it will probably be ready for distribution prior to the spray season next summer.

RALPH H. SMITH, *Associate Entomologists, University of California, Citrus Experiment Station*

A Note on the Relation Between Insecticidal Action and the Physical Properties of Soap Solutions.—In a study[1] published in 1929, it was shown that the kill produced by soaps as contact insecticides against the Japanese beetle varies strikingly with the kind of soap used. For example, with the potassium soaps produced from palm oil, corn oil, and castor oil, the per cent of beetles killed by an application of a spray containing 4 pounds of soap in 50 gallons of water (practically 1 per cent solutions) was 70, 50, and 2, respectively.

An effort has been made to find a correlation between certain physical properties of the soaps and their killing power. Since wetting and penetration are influenced greatly by the surface tension of the solutions, a determination of this property was made, using a Du Nouy surface tension apparatus. The surface tension was found to be fairly low in all cases, and no definite relation was found to exist between the surface tensions of the soap solutions and the killing power.

A microscopic examination of beetles sprayed with soap solutions was made for us by Mr. E. A. Richmond, formerly of this laboratory, with a view to determining whether there is any great variation in the penetration of the soap solutions into the

[1]A study of the insecticidal properties of soaps against the Japanese beetle, by P. A. van der Meulen and E. R. Van Leeuwen. Jour. Econ. Entomology, 22, 812–4 (1929).

spiracles and tracheae of the beetle. Mr. Richmond states that the penetration is substantially the same with the three soaps mentioned above.

It seems to be true that one obtains good wetting and penetration in all cases, owing largely to the fact that the surface tension of all the solutions is fairly low. It is evident that some factor other than surface tension plays a decisive role in this case.

As the rate of flow of a liquid through a tube of capillary dimensions is governed by the viscosity of the liquid, a determination of this property of the soap solutions was made at several concentrations, using a MacMichael viscosimeter. There did not appear to be any relation between the viscosity and the insect kill.

When 1 per cent solutions of the various soaps were placed on watch glasses and allowed to remain exposed to the air of the laboratory for a period of 15 to 30 minutes, it was found that the surface became covered in most cases with a skin of soap. Whether this skin or film consists of neutral soap, or whether it contains more or less of the acid soap, is not certain. It is a fact, however, that the films differ greatly in strength with the different soaps. In the cases of the potassium soaps, for example, the soap made from palm oil (70 per cent kill) forms a very tough skin which adheres very firmly to the watch glass. The same is true to a lesser extent of the potassium soaps made from beef tallow, coconut oil, mutton tallow, and cocoa butter (68 to 55 per cent kill). With the soaps made from lard, cottonseed oil, soy bean oil, and corn oil (54 to 50 per cent kill), the film either does not adhere to the watch glass, or is very easily loosened by blowing on the surface. With the potassium soaps made from neatsfoot oil, potassium oleate, menhaden oil, olive oil, and linseed oil (48 to 25 per cent kill), the film is not continuous, and does not adhere to the watch glass. The potassium soaps made from Japan wax, castor oil, rape oil, whale oil, and cod liver oil (8 to 2 per cent kill) either do not form a film at all, or else form very weak ones. There is very evidently a relation between the insect kill and this film formation. The soaps which form the toughest and most adherent films give the highest insect kill, and those which form less tenacious and weaker films give a lower kill, while absence of film formation corresponds to absence of kill.

In view of the importance of soaps as contact insecticides, it would be interesting to have this study extended to insects other than the Japanese beetle.

P. A. VAN DER MEULEN, *Agent, United States Department of Agriculture*
Moorestown, New Jersey

Hermetia illucens **L.—A Pest in Sanitary Privies in Louisiana.** During August and September, 1930, several complaints were received by the health authorities of Lincoln Parish, Louisiana, from persons living in rural districts on account of large numbers of wasp-like flies which were infesting their recently installed sanitary privies. The flies, which were identified by Mr. C. T. Greene of the Bureau of Entomology as *Hermetia illucens* L., were breeding in the privy pits, and whenever a seat cover was raised they would come out in swarms. In some cases a few sluggish individuals would crawl unnoticed into the underwear of the person using the privy. Due to the superficial resemblance of these flies to certain wasps, and the buzzing noise which they make when confined in close quarters, considerable consternation often resulted when a person lifted a privy lid and was greeted by a swarm of insects resembling wasps, or when upon leaving the privy he experienced a strange creeping and buzzing sensation due to flies being confined within his garments.

These conditions led some persons to abandon the new privies for those of the old surface type, while others were found to be tying the seat covers back to allow the flies to escape, and thereby admitting house flies and mosquitoes to the pit to breed. This situation was very trying to the health officials, who up to the time the fly nuisance began were receiving excellent cooperation from the people in the rural districts in a campaign for sanitation throughout the parish. F. C. Bishopp states that a similar situation was observed by him in central Florida in 1929.

The type of privy causing the nuisance is known to sanitary workers as the Virginia sanitary privy, which embodies the following features of construction: a vault or pit which is lined with wood and is covered at the top by the privy floor and seat box; a frame shed which is attached at the bottom to a curbing which surrounds the pit lining at the top; a vent pipe leading from the top of the seat box through and extending about two feet above the roof. The vent is made fly proof by a copper screen covering the bottom end where it rests on the seat box. The seat covers are hinged at the back with strips of automobile tire casing which operate as springs to make the covers self-closing. A mound of earth is built up around the base of the privy even with the floor which covers any cracks in the top of the pit lining and keeps the curbing from rotting rapidly. The privy is thus practically fly proof, the only chance of flies entering the pit being when a seat cover is open.

A short study of the situation showed that the adult *H. illucens* were depositing their eggs in cracks and in spider webs in the interior of the vent pipe. Some batches were found at the very top of the vent pipe under the rain cap. Upon hatching the larvae readily fall or crawl down through the screen at the bottom of the pipe into the pit where the larval and pupal stages are passed. The larvae serve to break up the solid excreta and thus hasten decomposition. All of the larvae do not pupate in the pit, as some are able to crawl up the perpendicular sides, escape through cracks, get into the earth outside and pupate near the surface close to the privy. This habit is an additional nuisance as chickens, in searching out the pupae, tear down the earth mound which is built around the privy and make it difficult to maintain.

A few tests with common oils, disinfectants and poisons showed that the larvae could be killed in pits in which the excrement was in a liquid state by a heavy application of gas oil, or in pits in which the excrement was semi-solid by a thin coating (about ¼ pound) of Paris green. Inasmuch as the flies are of little economic importance, however, it would appear that there is no need to advise either killing the larvae by poisoning, which treatment would certainly be neglected in most cases, and which would give those persons holding out against a sanitary privy installation an additional point for objection; or to devise a new type of vent pipe with more elaborate screening to prevent the pit from becoming infested, which would entail increased labor and care in construction and a slight increase in cost of materials. The best solution appears to be to devise a trap opening into the vault which will admit sufficient light to attract and capture the emerging flies or allow them to escape without admitting house flies and mosquitoes. The flies enter homes and visit foodstuffs very rarely, hence their escape is of no particular sanitary importance. Preliminary tests with traps designed to accomplish this purpose, located in the vent, in the floor, and in the seat box, are now in progress.

G. H. BRADLEY, *Division of Insects Affecting Man and Animals, U. S. Bureau of Entomology*

Rotenone as a Moth-proofing Agent.—Rotenone is one of the insecticidal constituents of derris root, cubé root, and other tropical fish poisoning plants. It is a crystalline material of the formula $C_{23}H_{22}O_6$, with a melting point of 163°C. It is quite insoluble in water, is very slightly soluble in petroleum oils, slightly soluble in alcohol and ether, and readily soluble in chloroform, ethylene dichloride, and other clorinated hydrocarbons.

Cooperative experiments conducted by the Federal Bureaus of Entomology and Chemistry and Soils, begun during June, 1929, and extending to date, have demonstrated that solutions containing 1 percent to 2 percent of rotenone dissolved in acetone, if used thoroughly to impregnate woolen goods, imparts a resistance to fabric pests that is of practical value, if conclusions can be drawn from laboratory tests run in petri dishes in accordance with the usual method now in vogue for testing moth-proofing solutions. Experiments involving *Tineola biselliella* Hum., *Anthrenus vorax* Casey, and *Attagenus piceus* Oliv. have proved the value of the rotenone solutions in acetone against these major fabric pests. In fact, even weaker solutions, some containing only 0.05 percent of rotenone, gave excellent protection. The protection, or moth resistance, imparted to the treated fabrics appears to equal that imparted by any proprietary moth-proofing solution now offered the public. Application for a Public Service Patent has been filed with the U. S. Patent Office by the U. S. Department of Agriculture.

E. A. Back and R. T. Cotton *Bureau of Entomology* and R. C. Roark,
Bureau of Chemistry and Soils U. S. Department of Agriculture.

CONNECTICUT ENTOMOLOGICAL WORKERS

The Seventh annual convention of Entomologists working in Connecticut was held in the old Senate Chamber, State Capitol, Hartford, on Friday, October 31, 1930. Subjects of vital importance to Connecticut were given a prominent place on the program, and several Federal Entomologists were invited to address the conference. The following Entomologists from outside of Connecticut presented papers: Lee A. Strong, Washington, D. C., C. H. Hadley, Camden, N. J., L. H. Worthley, Boston, Mass., A. F. Burgess, Melrose Highlands, Mass., and Donald S. Lacroix, Amherst, Mass. About 72 attended the conference. The following program was carried out without a single substitution except that on account of sickness Governor Trumbull was unable to be present:

Greeting, His Excellency, John H. Trumbull, Governor.

Qualifications and Training of Men for Agricultural Research, Director Wm. L. Slate, Agr. Expt. Station, New Haven.

Prominent Entomological Features of the Season, Mr. M. P. Zappe, Agr. Expt. Station, New Haven.

The Need of Organized Control of Plant Pests, Hon. S. McLean Buckingham, Commissioner of Agriculture, Hartford.

Certain Aspects of Federal and State Cooperation in Pest Control, Mr. Lee A. Strong, Chief, Plant Quar. & Control Admin., Washington, D. C.

Observations on Ant Lion Colonies, Mr. B. H. Walden, Agr. Expt. Sta., New Haven.

The Present Situation as Regards the Japanese Beetle in the United States, Mr. C. H. Hadley, In Charge, Preventing Spread of Japanese Beetle, Camden, N. J.

Control of the Squash Vine Borer, Dr. R. B. Friend, Agr. Expt. Sta., New Haven.

Survey of Corn Borer Conditions in the United States, Mr. L. H. Worthley, Administrator, Corn Borer Control, Boston, Mass.

Results of Scouting and Road Patrol in Connecticut, Mr. H. N. Bartley, Norwalk.

Shade Tree Insects and Control Methods, Dr. E. P. Felt and S. W. Bromley, Stamford.

Rearing and Liberating Parasites to Control the Oriental Fruit Moth, Dr. Philip Garman, Agr. Expt. Station, New Haven.

Present Status of the Gipsy Moth and the Satin Moth in New England, Mr. A. F. Burgess, In Charge of Moth Control, Melrose Highlands, Mass.

Early Entomological Work in Connecticut, Dr. W. E. Britton, Agr. Expt. Station, New Haven.

Some Entomological Observations, South, West and East, Dr. R. M. DeCoursey, Conn. Agr. College, Storrs.

Insects in the Childrens' Museum, Mr. J. S. Miller, Hartford.

Progress in Mosquito Elimination Work in Connecticut, Mr. R. C. Botsford, Agr. Expt. Station, New Haven.

Progress in Controlling the White Pine Blister Rust in Connecticut, Mr. J. E. Riley, Jr., Agr. Expt. Station, New Haven.

Insects Injuring Tobacco in Connecticut in 1930, Mr. Donald S. LaCroix, Amherst, Mass.

The following were present: Dorothy Amrine, New Haven; John T. Ashworth, Danielson; H. N. Bartley, Norwalk; John H. Belden, Hartford; H. L. Blaisdell, Melrose Highlands, Mass.; R. C. Botsford, New Haven; W. E. Britton, New Haven; Stanley W. Bromley, Stamford; Gladys Brooke, New Haven; S. McLean Buckingham, Hartford; A. F. Burgess, Melrose Highlands, Mass.; G. W. Burke, Shelton; T. M. Cannon, Hartford; V. L. Churchill, New Haven; C. W. Collins, Melrose Highlands, Mass.; O. B. Cooke, Danielson; R. G. Cooper, Colebrook; E. B. Davidson, Storrs; R. M. DeCoursey, Storrs; Charles M. Dittrich, Jr., Storrs; B. M. Ellis, Storrs; C. M. Emerson, East Hartford; E. P. Felt, Stamford; B. J. Fitzsimmons, Jr., Storrs; R. B. Friend, New Haven; C. W. Frink, Willimantic; Philip Garman, New Haven; R. D. Glasgow, Albany, N. Y.; C. H. Hadley, Camden; N. J.; Kenneth N. Hanks, Storrs; A. F. Hawes, Hartford; S. P. Hollister, Storrs; C. E. Hood, Melrose Highlands, Mass.; C. E. Jennings, New Haven; J. Peter Johnson, Shelton; J. F. Keough, Willimantic; Dolor LaBelle, Ballouville; Donald S. Lacroix, Amherst, Mass.; G. H. Lamson, Storrs; J. B. Lewis, Southington; J. W. Longo, Danielson; J. A. Manter, Storrs; J. A. McEvoy, Putnam; B. W. McFarland, New Haven; H. L. McIntyre, Albany, N. Y.; Dorothy E. Miller, Meriden; J. S. Miller, Hartford; E. S. Peterson, Shelton; Saul Phillips, Albany, N. Y.; G. E. Pinckney, Jr., Storrs; H. A. Preston, East Hartford; J. E. Riley, Jr., New Haven; R. M. Ross, New Haven; J. V. Schaffner, Jr., Melrose Highlands, Mass.; John C. Schread, New Haven; Frank R. Shaw, Belchertown, Mass.; M. T. Smulyan, Melrose Highlands, Mass.; Lee A. Strong, Washington, D. C.; J. F. Townsend, New Haven; Ethel Usher, Hartford; B. H. Walden, New Haven; R. L. Walker, Storrs; George S. Wheeler, Shelton; E. H. Wilkins, Hartford; A. E. Wilkinson, Storrs; L. H. Worthley, Boston, Mass.; M. P. Zappe, New Haven.

JOURNAL OF ECONOMIC ENTOMOLOGY

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The editors will thankfully receive news matter and other items likely to be of interest to our readers. Papers will be published as far as possible in the order of reception, except that papers of reasonable length may be accepted in the discretion of the editor for early publication at $2.50 per page for all matter in excess of six printed pages, a part page counting as a full page, this limit not including acceptable illustrations. Photo-engravings may be obtained by authors at cost.

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ANNUAL SCIENTIFIC MEETINGS: 1930-31, Cleveland; 1931-32, probably New Orleans; 1932-33, Chicago; 1933-34, undecided; 1934-35, probably Rochester.

Paris green was for many years the standard arsenical poison for insects. Its limitations became very evident in the early days of the gipsy moth work. The possibilities of arsenate of lead were worked out and it is now the standard arsenical compound used for the control of many insects. The spray residue problem has brought this latter compound into disrepute and a search is on for something better. It will be found, in all probability. The business of poisoning insects has grown to such a magnitude that only the best will suffice. There appears in this issue an account of tests with 283 materials made in a search for an acceptable substitute for arsenate of lead. This work is a suggestion as to what may be expected. The numerous studies of various phases of the insecticide problem are destined to result in important discoveries and we may reasonably expect valuable additions to the available insecticidal ammunition.

A recent Technical Bulletin on economic entomology gives temperature readings in the orchard in Fahrenheit degrees and the readings in experimental compartments in Centigrade, with an occasional indication of equivalents between the two. There is no question as to the greater convenience of metric units. There may be a question as to the advisability of using these in economic publications, even in technical bulletins, since presumably many copies of these would go to readers not sufficiently conversant with the two systems to make a ready transposition. It is perhaps equally obvious that a uniform system should be

followed throughout a publication and we would make no exception in the case of technical bulletins. From a practical standpoint, we are unable to see any great gain in using metric units wherever there is likely to be a more or less insistent need of transposition to the more generally accepted systems. Economic literature, technical or otherwise, has a very practical application and anything which tends to render this more difficult for the general reader defeats in a measure at least, the purpose of the publication.

Obituary

EDWARD FOSTER

Many entomological visitors to New Orleans during the past quarter century and more will regret the passing of the genial "Ed Foster," widely known as an amateur entomologist, collector and naturalist. Mr. Foster died at his home in New Orleans on October 8, 1930, aged 67, having been confined to his bed since February.

Mr. Foster, a native of England, came to New Orleans in his early twenties. He was of an old English family, and was a nephew of Lord Halliburton. He had a brilliant mind and an excellent education. His memory was amazing. It was said that he could give as much information on any subject as a small encyclopedia.

He was at first employed in New Orleans in a cotton firm. He afterwards joined the staff of the old *Picayune*, and it was his duty to report the activities of the Board of Trade, the Cotton Exchange, the Sugar Exchange, etc. "He ranked high as a journalist," says a newspaper article, "and was regarded as one of the best posted editorial writers, especially on commercial subjects." He took a prominent part in the eradication of yellow fever from New Orleans. When *The Picayune* merged with *The Times-Democrat* (forming *The Times-Picayune*), Mr. Foster became connected with the Louisiana Experiment Stations. He was afterwards employed for a while as an assistant at the Mound, La., laboratory of the Bureau of Entomology. Later he became an entomologist for the Louisiana Department of Agriculture. He held this position till his death. For many years he was also the Louisiana reporter for the New York sugar journal, *Sugar*.

Though possessed of a wide knowledge of insects, he was not a prolific writer on entomology. In fact, the only contribution known to the undersigned is, "The Introduction of *Iridomyrmex humilis* (Mayr) into

New Orleans," published in THE JOURNAL OF ECONOMIC ENTOMOLOGY, Vol. 1, pages 289–293, 1908. However, he was generous in sharing his knowledge with other workers, and he would often direct one's attention to some obscure publication or reference. For some years he was engaged in making a card index of publications on the insects of Louisiana. This was in addition to his regular duties.

Mr. Foster was one of the founders of the Louisiana Entomological Society, in 1920, being its first president. He also held the position of secretary-treasurer for a long time.

His wife died two years ago. Two children, Mr. Edward Foster, Jr., and Mrs. Clay W. Brooks, survive.

Mr. Foster's death causes a real vacancy in the entomological circles of New Orleans and Louisiana.

T. E. HOLLOWAY

Reviews

The Biological Control of Insect and Plant Pests, by W. R. THOMPSON, pp. 1-124, H. M. Stationery Office, London, 1930.

Every one interested in the biological control of either insect or plant pests would benefit by the opportunity of studying this most excellent report on the "Organization and Progress of the Work of the Farnham House Laboratory," which was founded by the Imperial Bureau of Entomology some three years ago, by means of a grant from the Empire Marketing Board, with the main object of the furtherance of the control of insect pests of agriculture and forestry by means of what is known as the biological method. The first grant of the Empire Marketing Board was for 15,000 pounds for capital expenditures and 5,000 pounds per annum for maintenance expenditures during the following five years. Due to the rapid development of the work of the Laboratory, the funds allotted for annual maintenance proved decidedly inadequate, and the Imperial Bureau, after a conference with representatives of the Empire Marketing Board, secured a grant of an additional 2,000 pounds per annum from 1st July, 1929. In 1929 also, at the request of the New Zealand Government, the Laboratory took over the conducting of the European end of the work on the insect enemies of New Zealand weeds and received from the New Zealand Government a special grant of 1,000 pounds per annum for this work. Small subsidies have been made by the Commonwealth Council for Scientific and Industrial Research in Australia, the New Zealand Government, the Government of Cyprus, etc.

The Farnham House Laboratory is located in a 15-room country house about 25 miles from London, with about 6½ acres of ground thereabout. From the description in part III of the present report, the Laboratory and grounds would seem to be excellently and most modernly equipped for the work in hand and supplied with a highly competent staff.

Dr. Guy A. K. Marshall, the well-known Director of the Imperial Bureau of Entomology, in his preface to the report considers that the creation of the Labora-

tory has met a real need in imperial entomology, as proven by the response of the dominion and colonial entomologists to offers of assistance. Even before the Laboratory was open for work, requests for help were received, and up to this time the list of injurious insects and plants which the Laboratory has been asked to investigate with the hope of finding natural enemies comprises some 70 species. An idea of the widespread diversification of the investigations under way may be obtained from the fact that the Dominion of Canada alone has submitted to the Laboratory projects involving the natural control of no less than 28 species of injurious insects, while Australia has submitted 16; New Zealand, 14 projects of insects and 5 of obnoxious weeds; South Africa, a project of biological control of the Sheep Blow-fly; India, projects of Woolly Aphis and Fluted Scale; West Indies, one on Pink Boll Worm; Cyprus, on Codling Moth and Potato Tuber Moths; the Falkland Islands, on Blue Bottle Fly; and the United States of America, a project of the Pink Boll Worm and the Carrot Rust Fly. Up to the date on which this report was sent to press last June, a total of 73 consignments of beneficial insects, containing approximately 285,000 living individuals, was sent out by the Laboratory. These shipments included some 24 species of beneficial insects attacking 17 species of pests. So much for the actual progress of the work of this splendid institution which is materially adding to our knowledge of both theory and practice of biological control of agricultural pests!

Probably of most interest from the reviewer's standpoint, however, is part II of the report, which is devoted to a general account of the problems encountered in biological control operations with special reference to the organization and practical conduct of work in this, as yet, comparatively unexplored and most promising field in economic entomology. As Dr. Thompson mentions in his brief introduction, a certain number of purely theoretical considerations have been included because of their value in indicating lines of research in both field and laboratory, and, in view of the clear and concise manner in which these theoretical considerations have been handled by the author, there should be no doubt that their inclusion has added to the practical value of the work. The great majority of the statements and suggestions, however, are the fruit of a generation of practical work in this field and have the seasoned value of having been repeatedly tested and practiced. This section of the report constitutes one of the most complete and understandable outlines of the whole technique of biological control that the writer has yet seen published.

The report calls attention to the perhaps little known fact that of the 183 worst known enemies existing in North America practically half have been introduced from foreign countries, the larger proportion coming from Europe. The damage caused by the Hessian-fly in the United States is something like 800,000 pounds each year, while the cost of the by no means complete control of the Gypsy Moth, accidentally introduced into the United States some 60 years ago, is costing that government something like 50,000 pounds per annum. The European Corn Borer, an unwelcome immigrant to the United States but a decade and a half ago, is the cause of appropriations aiming at its control of around 100,000 pounds annually, altho in the single year of 1927 alone 2,000,000 pounds were expended in an attempt to arrest its spread. The loss or expense now being caused in the United States by the Oriental Peach Moth, the Japanese Beetle and the quite contemporaneous Mediterranean Fruit Fly serves to demonstrate the enormous field for the biological control of such pests.

Dr. Thompson emphasizes the need of preparatory work when the entomologist is requested to utilize the method of biological control in order to prevent damage by any pest. Of course, the first step is the accurate diagnosis of the cause of the injury and in this connection the vital importance of ready access to the councils of experienced systematists and to adequate collections and libraries is stressed. Next must come a thoro study of the literature and tabulating of the information thus obtained and then the preliminary field survey as indicated by the data in hand. The mapping out of bio-climatic areas, even tho, due to lack of complete data, this must be done quite roughly, is one of the first essentials in planning a satisfactory preliminary survey, inasmuch as frequently under one set of edaphic conditions a certain parasite may be more or less effectually controlling its host, while under a different set of conditions this particular parasite may be of no practical value. After it has been decided in just what regions the preliminary collections shall be made, the points within that region likely to give a representative idea of the conditions as a whole must be selected. It is desirable to have in headquarters a collection of the most important works dealing with the climatic, agronomic and biological characteristics of the main areas in which the work is to be carried out, also as complete a collection as possible of detailed and accurate maps. Once the survey and conclusions have been made, the examination of the material at the laboratory logically follows, with particular attention to proper determination of parasites and hyperparasites, after which the choice of the species to be utilized can be made as well as the decision as to the advisability or otherwise of introducing several parasitic species simultaneously or attempting to obtain a certain measure of control thru the initial use of one promising species to be supplemented at later dates by the introduction of others. Apparently the policy of the Farnham House Laboratory in general is to introduce one natural enemy at a time and observe the effect of this before proceeding further.

Now comes the large-scale collection and shipment of the parasites or predators, and under this heading there are complete and practical suggestions given for the speedy and economic conduct of this very important phase of the operations. The section on the method of treatment on reception and that on the study of the progress of introduced parasites in the field are also carefully and illuminatingly discussed.

This section of the report concludes with a highly theoretical and yet clearly put discussion of the results of experiments in biological control in general. Many interesting mathematical considerations as well as strictly biological ones are included in this section but the whole subject is such a complicated and involved one that no attempt may be made to review it in this limited space.

Appended to the report is an excellent bibliography of biological control of agricultural pests in which are listed 95 articles selected from the voluminous and somewhat chaotic literature of the subject.

A. H. ROSENFELD

Current Notes

W. C. Kelley, Alabama Polytechnic Institute, has been appointed Instructor in Zoology-Entomology during the absence of Professor F. S. Arant.

Prof. Geo. A. Dean returned to Manhattan, Kansas, on Sept. 29th, after a three months' visit to various sections of Europe—from Sweden to Italy.

F. H. Shirck Bureau of Entomology has been transferred from Toppenish, Wash., to Parma, Idaho, and K. E. Gibson has been transferred from Walla Walla, Wash., to Toppenish, Wash.

The Department of Zoology-Entomology, of the Alabama Polytechnic Institute, has completed a copper wire insectary, consisting of eight compartments, to augment the facilities for research in entomology.

E. E. Blanchard, Entomologist of the Department of Agriculture in Argentina, who has been attending the Pan American conference on agriculture recently held in Washington, visited the Division of Insects September 22 and subsequently.

Professor F. E. Guyton of the Department of Zoology-Entomology, Alabama Polytechnic Institute, spent the summer quarter at the Ohio State University Biological Laboratory, Put-in-Bay, Ohio pursuing graduate work toward the doctorate.

H. S. Swingle, who is in charge of the insect physiology research of the Department of Zoology-Entomology of the Alabama Polytechnic Institute has been assigned 2500 sq. ft. of new Laboratory space, which is fully equipped.

R. E. Campbell, Bureau of Entomology, in charge of the field laboratory at Alhambra, Calif., reports that Dr. N. S. Scherbinovsky, Commissariat of Agriculture of the U. S. S. R., Moscow, Russia, visited the field laboratory at Alhambra on September 2, 3 and 4.

Dr. Henry G. Good has been placed in charge of the collections of the Department of Zoology and Entomology at the Alabama Polytechnic Institute. More ample space and arrangement has recently been provided for this phase of the work.

Professor F. S. Arant, of the Department of Zoology-Entomology, Alabama Polytechnic Institute, who is on leave, has accepted a teaching fellowship at Iowa State College, Department of Zoology-Entomology, and is taking full time work toward the doctorate.

Erskine M. Livingstone was appointed Junior Entomologist, Bureau of Entomology, September 18. He graduated last June from the Clemson Agricultural College, S. C., and will assist W. D. Reed in the investigation of insects affecting cured tobacco, with headquarters at 515 Jefferson Street, Danville, Va.

Probationary appointments in the Bureau of Entomology to the several grades named have been given W. C. Cook, Entomologist, Davis, Calif., G. T. York, Junior Entomologist, Riverside, Calif., and W. B. Hollingsworth, Junior Entomologist, Picayune Miss., who have been assigned to duties at the addresses stated.

J. A. Beal, Bureau of Entomology, spent the field season at Klamath Falls, Oreg., studying the effect of various methods of slash disposal upon populations of bark beetles. He has found that piled slash breeds nearly four times as many beetles as that scattered on the ground and exposed to the sun.

Doctor A. L. Strand of the University of Minnesota has accepted the appointment as Head of the Department of Entomology, Montana State College, Bozeman,

succeeding Profeessor R. A. Coloy who will devote himself to research work. The appointment carries with it the positions of Entomologist of the Experiment Station, State Entomologist, and Secretary of the State Board of Entomology. Doctor Strand was a graduate in Entomology from Montana State College in 1917 and received his Master of Science and Doctor of Philosophy Degrees from the University of Minnesota.

C. P. Clausen, Bureau of Entomology, who has been in the Malay Peninsula and Dutch East Indies since the spring of 1929, collecting parasites of the citrus black fly, arrived in the United States September 17, with several cases of material. He spent September 18 and 19 in Washington, conferring with Bureau officials in regard to this work.

Mr. W. J. Brown, Entomological Branch, who has been collecting insects on the North Shore of the Gulf of St. Lawrence at Thunder River, Natashkwan and Bradore Bay, since the middle of June, returned to Ottawa on September 1. Mr. Brown reports a very successful collecting season, which will result in many valuable additions to the National Collection.

On July 1st the following men were promoted in rank in the Department of Entomology at the Kansas State Agricultural College: Dr. R. L. Parker was promoted to the rank of Professor of Apiculture and Entomology, Dr. R. H. Painter was promoted to an associate professorship and Mr. D. A. Wilbur was raised to an Assistant Professor of Entomology.

Dr. Emily W. Emmart, Bureau of Entomology has been appointed Assistant Entomologist, and assigned to study the morphology and histology of the Mexican fruit fly as it develops under different environmental conditions. Her headquarters will be at Mexico City, where she reported for duty September 22. Dr. Emmart recently received her doctor's degree from Johns Hopkins University.

Professor N. S. Scherbinovsky, principal entomologist of the Commissariat of Agriculture of the Union of Socialistic Soviet Republics, Moscow, Russia, visited the field laboratory at Alhambra, Calif. September 2–4 and the field laboratory at Tallulah, La., September 17 and 18.

P. H. Timberlake, of the Graduate School of Tropical Agriculture and Citrus Experiment Station, Riverside, Calif., arrived in Washington on September 16, and plans to remain for the winter, working on the classification and identification of coccinellid beetles. Special attention will be given the Keobele collection of specimens belonging to this family, which has been shipped to him in Washington from the Hawaiian Sugar Planters' Station.

A collection of Diptera, totalling approximately 12,000 specimens, has been presented to Purdue University by Dr. C. F. Adams, Director of the Bacteriological Laboratory of the Indiana State Board of Health and formerly Dean and Entomologist of the College of Agriculture of the University of Arkansas. Dr. Adams has retained the Mycetophilidae and a named set of the Culicidae, in which groups he will continue his studies.

On September 5, C. K. Fisher, Bureau of Entomology, of the bean-weevil field laboratory at Modesto, Calif., began the annual check on the infestation of the bean crop as delivered in the warehouses in California. The hearty cooperation of warehousemen and State and County agents is being extended to Mr. Fisher, as in the past. The percentage of infestation for 1930 promises to be very low as compared with that of previous years.

Donald DeLeon, Bureau of Entomology, of the field laboratory at Coeur d'Alene, Idaho, has been located at Metaline Falls, Wash., during the season, where he is making an intensive study of all insects found in association with *Dendroctonus monticolae* in white pine. The purpose of this study is to determine what insects contribute to the prevention of epidmics of Dentroctonus, in the hope that artificial control can be so directed as to take full advantage of such agencies.

Dr. L. L. English, who is located at Spring Hill, Alabama, recently conferred with the central office at Auburn regarding the completion of the new Entomological Field Research Laboratory which is being donated to the department of Zoology-Entomology by the Mobile Chamber of Commerce and the County Commissioners. The new laboratory is especially designed for research on insects affecting citrus trees and fruits. It is fireproof throughout. The laboratory equipment, and six acre experimental farm was obtained at an approximate cost of $25,000.

A. O. Larson, Bureau of Entomology, reports that examinations made in one 40-acre field in Oregon, planted for the third consecutive year in field peas, showed that 91½ per cent of all peas produced were weevily. He estimated that in this field 47,000,000 adult weevils were left behind in the stubble after harvest. While this is an extreme case of infestation, it is sufficient to indicate the interest of northwestern farmers in the investigations on the pea weevil, of which Mr. Larson assumed charge July 1.

Dr. Arthur Gibson returned to Canada from England early in August, landing in Montreal on August 9. He reported that the Third Imperial Entomological Conference, held in London, at which representatives were present from practically all of the Dominions and Colonies of the British Empire, was a success. He also spent several days at the Farnham Royal Parasite Laboratory conferring with Dr. W. R. Thompson. Certain research stations in the neighborhood of Paris, and also the United States Parasite Laboratory at Hyeres, in southern France, were visited.

In August F. P. Keen, Bureau of Entomology, made an inspection of the National Forests of Washington. He did this to familiarize himself with insect conditions in this portion of the territory assigned to the United States Entomological Laboratory opened at Portland, Oregon., in October, 1929. Heavy damage by insects was found in various forests. The Douglas-fir tussock moth has killed thousands of acres of fir on the Colville National Forest, and the mountain pine beetle is causing severe damage to the pines both east and west of the Cascade Range.

W. B. Cartwright, Bureau of Entomology, has returned from the Orient, where he spent the last two and one-half years collecting and forwarding to the United States, parasites of the European corn borer. It will be remembered that C. A. Clark reported to Mr. Cartwright in Japan in September, 1929, in order that he might become familiar with the parasite work before taking charge of the work initiated by Mr. Cartwright. After clearing up several questions regarding the parasite work, Mr. Cartwright will resume charge of the field laboratory at Sacramento, Calif.

The latter part of July was spent by J. C. Evenden, Bureau of Entomology, of the forest-insect field laboratory at Coeur d'Alene, Idaho, in checking the results of control projects instituted last spring on the west side of Glacier National Park, and in examining areas containing new outbreaks. The results obtained by the control projects were very gratifying, as only a few newly infested trees could be found within the areas covered by control. Examination revealed several serious situations that will require control measures during the fall of 1930 and the spring of 1931.

Dr. Filippo Silvestri, Director of the Royal School of Agriculture at Portici, Italy, spent much of his time from September 6 to September 10 working on insects in the National Museum collections, with various specialists of the Bureau. He was particularly interested in termites, Zoraptera, coccids, and various myrmecophilous and termitophilous forms. Two collecting trips were made during his stay, one with Doctor Chapin, to locate living specimens of *Zorotypus hubbardi* Cdll., the other with Mr. Barber and Doctor Snyder, to search for specimens of Micromalthus, Machylis, and Spirobolus, upon which he has uncompleted manuscripts.

During a period of leave of absence in the United States, Mr. L. S. McLaine, Entomological Branch, visited the Connecticut Experiment Station, New Haven, and discussed the Asiatic and Japanese beetle situation with Dr. W. E. Britton, State Entomologist. While there he studied the methods and technique of rearing various insect parasites of the oriental peach moth. In New York City, on August 8, Mr. McLaine paid a visit to the officers of the Plant Quarantine and Control Administration regarding the European corn borer and Japanese beetle, and discussed the question of the inspection of export shipments to Canada.

A general conference on the European corn borer was held at Toledo, Ohio, September 24 and 25. The meeting this year was in many ways more comprehensive and instructive than such meetings have been in the past, although rainy weather interfered considerably with the original plans. Information was released on the status of the borer for the present season, including spread and abundance. Detailed reports were given on the various phases of research. There was the usual large attendance, representing farmers, business and banking interests, manufacturers of agricultural machinery, and State and Federal officials. A complete report of the conference is now available.

At the request of Col. D. C. Chapman, Chairman of the Tennessee Great Smoky Mountain Park Commission, Doctor Craighead and Mr. St. George, Bureau of Entomology, visited several parts of the Smoky Mountain National Park on September 10 and 11, investigating extensive outbreaks of the southern pine beetle. What is believed to be one of the largest outbreaks in recent years was found in that park. Of particular interest was an outbreak of this beetle found in spruce. This is the first record for this host in many years. Many local outbreaks in pine were found in various localities in western North Carolina and in eastern Tennessee.

The Gipsy-Moth Laboratory moved to new quarters at 1156 Main Street, Melrose Highlands, Mass., on October 15. The new location is about one-half mile from the former quarters at 17 East Highland Avenue, and can be as easily reached by railroad or by electric car from Boston. The buildings on the new site are constructed of cement blocks, and consist of two main structures and garage stalls. The largest building is being made ready for use as a laboratory, and some of the insectary buildings belonging to the laboratory have already (September 30) been moved to land adjacent to the new quarters.

The tenth annual meeting of the International Great Plains Crop Pest Committee was held under the auspices of the Dominion Entomological Laboratory, Lethbridge, Alta., on August 28–30, 1930. The meetings were held at the Greenhill Hotel, Blairmore, Alberta, and were attended by the following: Mr. H. G. Crawford, Chief of the Division of Field Crop and Garden Insects, Ottawa; Prof. R. A. Cooley and Mr. G. A. Mail, of the Montana Experiment Station, Bozeman, Montana; Dr. J. R. Park-

er, of the U. S. Bureau of Entomology, Bozeman, Montana; Dr. M. C. Lane of the U. S. Bureau of Entomology, Walla Walla, Wash.; Prof. B. H. Strickland, University of Alberta, Edmonton; Mr. S. H. Vigor, Field Crops Commissioner, Regina, Sask.; Messrs. N. Criddle and R. H. Handford, Entomological Laboratory, Treesbank, Man.; Mr. Brown of the Inspection Station, Estevan, Sask.; Mr. K. E. Stewart, Entomological Laboratory, Indian Head, Sask.; Messrs. K. M. King, E. McMillan and L. Paul of the Entomological Laboratory at Saskatoon, Sask.; Mr. E. R. Buckell of the Entomological Laboratory at Vernon, B. C.; Mr. Eric Hearle, of the Entomological Laboratory at Kamloops, B. C.; Messrs. H. L. Seamans, G. F. Manson, C. W. Farstad, R. W. Salt and J. H. Pepper, of the Entomological Laboratory at Lethbridge, Alberta; Dr. Neidig of the Consolidated Smelters, Trail B. C. and Mr. F. S. Carr of Medicine Hat, Alberta. Miss C. Coutts of the Entomological Laboratory of Lethbridge, Alberta, was secretary of the meetings.

Horticultural Inspection Notes

The Eastern Plant Board has scheduled a meeting to be held in New York City on November 24 and 25.

Mr. O. L. Cook has been transferred from the port of Nogales, Arizona, to Eagle Pass, Texas.

Mr. Joseph T. Watt has been transferred from the port inspection at Eagle Pass, Texas, to Honolulu, T. H., to assist Mr. H. F. Willard.

Mr. A. K. Pettit, who was formerly employed as a Plant Quarantine Inspector at Eagle Pass, Texas, was reinstated on September 17 for duty at the port of New Orleans.

Mr. and Mrs. R. N. Lobdell, who had for a number of years been employed by the State Plant Board of Mississippi, resigned their positions in April, 1930. They are now located at Belle Glade, Fla., where Mr. Lobdell is Entomologist of the Everglades Branch Experiment Station.

On September 3, Mr. R. W. Woodbury was transferred from Boston to assume charge of the Plant Quarantine activities at the port of Wilmington, North Carolina. Mr. J. T. Beauchamp was appointed Junior Plant Quarantine Inspector to fill the vacancy at the port of Boston, Massachusetts.

Messrs. Harry M. Cottier, Fred O. Dodd, Hubert G. Frane, William R. Fyke, John R. Garrett, Mansel C. Guerry, Clyde G. Latham, J. Guy Lewis, Milton H. Sartor, and H. G. Taylor, have been appointed as Junior Plant Quarantine Inspectors and assigned to the port of New York.

The Commissioners and Secretaries of Agriculture held their annual meeting in Washington on October 20 to 22. The work of the Plant Quarantine and Control Administration of the United States Department of Agriculture was discussed by Mr. Lee A. Strong in one of the sessions of the convention.

Mr. L. M. Fenner, until recently employed as Associate Plant Pathologist of the State Plant Board of Florida in connection with control or prevention of spread of the bacterial canker of tomato, has resigned to take postgraduate work in the Department of Botany at Ohio State University, Columbus, Ohio.

Continuing the series of circulars giving the plant quarantine restrictions of various foreign countries, the Plant Quarantine and Control Administration has issued outlines of the requirements of Brazil (PQCA-294), Union of South Africa (PQCA-297) and Australia (PQCA-299).

Under recent rules adopted by the State Plant Board of Mississippi, the shipment into that State of nursery stock from areas in other States in which the Ozonium Root Rot (*Ozonium omnivorum*) is known to occur, is prohibited, also shipments from nurseries and greenhouses known to be infested with the Japanese Camphor Scale (*Pseudaonidia duplex*).

Mr Chesley Hines, who had served as Inspector for the State Plant Board of Mississippi since January, 1927, with headquarters at Yazoo City, where he had charge of the Plant Board work in five counties, resigned on October 15, 1930, to accept the position of Fruit Specialist in the Extension Department at A. & M. College, Mississippi.

Mr. T. F. McGehee, who had for ten years been Assistant Entomologist for the State Plant Board of Mississippi with headquarters at Holly Springs, where he had charge of the Plant Board work in three counties, resigned on September 1, 1930, to accept the position of Assistant Director in charge of the Branch Experiment Station at Holly Springs, Mississippi.

A modification of the instructions for the disinfection of nursery products under the requirements of the Federal Japanese beetle quarantine regulations was issued on September 17 to authorize the lifting of plants from fields previously treated with lead arsenate, on October 1 instead of October 15, as heretofore.

Mr. R. A. Sheals of the Domestic Plant Quarantine Office of the Plant Quarantine and Control Administration spent the month of October visiting transit inspection stations in the Middle West, for the purpose of supervising the work of transit inspectors during the fall nursery stock shipping season.

The Plant Quarantine and Control Administration reports the discovery of the pink bollworm of cotton at a number of points in Arizona in the Salt River Valley, and the Gila Valley, outside the noncotton zones established by the State of Arizona early in 1930, in an attempt to eradicate the pink bollworm from that section.

Mr. B. C. Stephenson, a recent graduate of the Mississippi A. & M. College, who has been employed since March, 1930, as an inspector for the State Plant Board with headquarters at Greenwood, Miss., where he had charge of the Plant Board work in three counties, resigned on October 29, 1930, to accept an appointment in the Mexican fruit worm eradication work with headquarters at Harlingen, Texas.

A rule of the State Plant Board of Mississippi adopted in 1930 prohibits the movement into or within Mississippi of potted plants or any other plants with soil around the roots from areas known to be infested with the Argentine ant (*Iridomyrmex humilis*) except when the State Plant Board shall receive reliable information that the property on which the plants were grown is free from the ants.

Messrs. J. S. Woodard, Austin, Texas; M. S. Yeomans, Atlanta, Ga.; G. M. Bentley, Knoxville, Tenn.; R. W. Leiby, Raleigh, N. C.; P. A. Glenn, Urbana, Ill.; R. H. Bell, Harrisburg, Pa.; E. N. Cory, College Park, Md.; and W. E. Rumsey, Morgantown, Va., were among the State nursery inspection officers who attended the phony peach disease quarantine hearing at Washington, D. C., on November 14.

At a special meeting of the State Plant Board of Mississippi held on October 4, 1930, the quarantine against the sweet potato weevil, *Cylas formicarius*, was amended so as to remove from the quarantined area Baldwin County, Alabama, and the northern part of Mobile County, Alabama. The only part of Alabama that is now within the quarantined area is that part of Mobile County that lies south of the north line of Township 4 south.

Mr. W. B. Hollingsworth, a recent graduate of the Mississippi A. & M. College, who had been employed as an Inspector for the State Plant Board of Mississippi since March, 1930, resigned on September 1 to accept an appointment as Junior Entomologist in the Division of Truck Crop Insect Investigations of the United States Bureau of Entomology with headquarters at Picayune, Miss., where he is engaged in investigations on the sweet potato weevil.

During the latter part of October, Mr. E. R. Sasscer, in company with Dr. J. H. Montgomery, visited several ports of entry in Florida and also the island of Cuba. While in Cuba, Mr. Sasscer was in conference with Mr. Ernesto Sanchez Estrada concerning methods employed in safeguarding the arrival of airplanes from foreign countries. On his return trip to Washington, Mr. Sasscer conferred with the inspectors in charge at the ports of Savannah, Ga., Charleston, S. C., and Wilmington, N. C.

Because a reduced appropriation for the support of the State Plant Board of Mississippi made some reorganization of the work in that State necessary, the policy of inspecting all nurseries in the State at least three times each year has been abandoned. The present policy is to inspect all commercial nurseries at least twice each year. All citrus nursery stock is inspected at least three times each year. Small nurseries that are not large enough to be considered of commercial importance, and that do not contain citrus plants, are inspected only once each year unless there is some special reason for additional inspections.

A revision of the Japanese beetle quarantine and regulations was issued by the United States Department of Agriculture to become effective on November 10. Under the revision the entire State of Rhode Island and parts of Delaware, Massachusetts, New York, Pennsylvania, and Virginia were added to the regulated areas. The District of Columbia and small sections of Virginia, Connecticut and Pennsylvania were transferred from the lightly infested to the generally infested area, and parts of two counties in Maryland were transferred from the generally infested to the lightly infested area.

The discovery of the pink bollworm in Eddy and Otero Counties in New Mexico in October, after its apparent absence in those counties for the past two years, caused the United States Department of Agriculture, effective October 20, to reinstate the requirement of fumigation of cotton lint and linters produced in those counties as a condition for the issuance of permits for the interstate movement of cotton produced in those areas to points outside the regulated area of New Mexico. The infestations on which the new order was based were discovered at Loving, Artesia, Malaga, and Tularosa.

Prof. W. C. O'Kane, Durham, N. H., who has been in charge of Federal activities directed against the Mediterranean fruit fly in Florida since Dr. Wilmon Newell resigned as executive officer in March, relinquished his connection with that work on

October 15 to return to his duties at the University of New Hampshire. He was succeeded at Orlando, Fla., by Mr. Paul A. Hoidale, who has charge of the work conducted under the Administration against the Mexican fruit worm in Texas. Mr. M. H. Ford has been acting in charge of the Mexican fruit worm activities in Harlingen, Tex., since Mr. Hoidale's departure.

New appointees to the Federal port inspection service and the points to which they have been assigned include the following: Lionel A. Mayer, Norfolk, Va.; Geo. F. Callaghan, Erastus W. Ingle, Ralph T. Kyzar, and John P. Williamson, Brownsville, Texas; Thomas P. Chapman and Hahn W. Capps, Calexico, California; H. A. Berrier, Del Rio, Texas; T. A. Barnett, John E. Downs, and J. N. Smith, Douglas, Arizona; W. C. Goolsby, Eagle Pass, Texas; Albert E. Archer, Harry R. Conway, W. A. Harvison, and Edward Smith, El Paso, Texas; Amis L. Williamson, Hidalgo, Texas; C. L. Ritchie, Naco, Arizona; Byrd M. Ault, Edgar C. Harrison, Wm. F. Maner and W. B. R. Stromberg, Nogales, Arizona; John H. Russell, Presidio, Texas; J. F. Altstaetter, San Ysidro, California, E. L. Friday, Zapata, Texas; O. D. Morris, New Orleans; Uhl R. Kuhm, Virgil O. Miller, Bernard P. Stewart and Malcolm G. Vinzant, Laredo, Texas.

The Minister of Agriculture and Fisheries of England reports that in a number of instances shipments of plants from the United States have arrived in that country bearing State certificates which cover seasonal nursery inspection rather than inspection of the nursery stock within fourteen days prior to the date of shipment as required for the importation of plants into England and Wales. As the State plant quarantine officers of a number of States report difficulty in meeting the 14-day requirement, arrangements have been made by the Plant Quarantine and Control Administration, under the export certification act, to inspect such shipments at the port of departure in instances where State inspection is impracticable.

At a special meeting of the State Plant Board of Mississippi held on October 11, 1930, Rule 24-A was amended by the addition of the following paragraph: "The transportation through Mississippi enroute to other States of sweet potatoes, sweet potato plants, vines, cuttings, draws, and slips originating in territory, defined above as infested with the sweet potato weevil, is hereby prohibited except when accompanied by a certificate of inspection from the plant inspection official of the State of origin. This certificate must state that the sweet potatoes, or sweet potato plants were carefully inspected and found to be apparently free of the sweet potato weevil and also that the property on which the sweet potatoes or sweet potato plants were grown had recently been inspected and found to be apparently free of the sweet potato weevil."

On November 14, a hearing was held before the Plant Quarantine and Control Administration and the Federal Plant Quarantine Board to consider the extension of the quarantine on account of the phony peach disease to the States of North Carolina, South Carolina, Mississippi, Tennessee, Louisiana, Arkansas, and Texas. As an alternative to such extension, the question as to the possible discontinuance of the quarantine was also discussed. No action has yet been taken as a result of this hearing. The Administration announced that scouting work during the summer of 1930 disclosed infections, most of them incipient, in six counties in Texas, four counties in Arkansas, four parishes in Louisiana, two counties in Tennessee, one county in North Carolina, ten counties in South Carolina, and eighteen counties in Mississippi,

in addition to several counties in Alabama and Georgia, outside the areas of those States now regulated under the phony peach disease quarantine.

Mr. George L. Knight, Chief of the Division of Horticulture of the Montana Department of Labor and Industry reports that there are now sixteen inspection points in that State, each manned by an inspector who is on duty throughout the year, and that there is an additional inspector at Hamilton, Montana, making a total of seventeen field inspectors connected with his office. Of these, ten are engaged at least part of the time in inspecting incoming and outgoing nursery stock, eight represent both the Federal Bureau of Agricultural Economics and the State Division of Horticulture in the examination of apples as to quality and grade, fourteen make similar examinations of potatoes, and several in addition inspect such products as beans, lettuce, and onions as to quality and grade in addition to their work as plant quarantine officers.

The Secretary of Agriculture announced on November 17, an amendment to the pink bollworm quarantine regulations releasing from all restriction under that quarantine considerable portions of western Texas including the entire counties of Midland and Glasscock, all those portions of Dawson, Borden and Howard counties formerly under regulation, and a small portion of northeastern Midland County. No pink bollworm infestation has been found in any part of the released area at any time, except during the drop season of 1927. Surveys at that time showed some twenty different fields scattered through this area to have been subject to infestation. The eradication campaign which was immediately undertaken was apparently successful as scouting during and following the crop seasons of 1928, 1929, and 1930 have given uniformly negative results. The surveys for the season of 1930 were especially intensive due to the development of a machine which aids in separating insect material from gin trash and thereby enormously increases the rapidity with which gin trash can be examined.

The Federal Mediterranean fruit fly quarantine, relating to the transportation of Florida products susceptible to fruit fly infestation, was lifted November 15. This action completely removed all remaining restrictions on the interstate movement of host fruits and vegetables from the regulated area of Florida. Only a very few specimens of the fruit fly have been found in the State during the past fourteen months and none have been discovered since August 1, 1930. The nearly 700 inspectors employed during the late summer and fall submitted approximately 600,000 specimens for examination by the identification division but none were identified as being Mediterranean fruit fly. Prior to the removal of the regulations, three amendments were issued to the revision which had become effective on August 15. These amendments removed the sterilization requirements as to the shipment of host fruits and vegetables billed to southern and western states, the regulations requiring the cleaning of railway cars which had been used in transporting restricted articles out of the regulated area, the restrictions on the re-shipment of Florida products from northern to southern and western States, all restrictions on the shipment of host vegetables produced outside the "infested areas", and the regulation which prohibited the transportation of Florida host fruits and vegetables by trucks and other road vehicles. One of the amendments had also released three additional counties from the regulated areas. The principal restriction remaining up to the time the Federal quarantine was lifted required owners to pick up and dispose of "drops," culls and windfalls, made certain requirements as to packing house sanitation and provided for the issuance of property certificates and shipping permits. Intensive field inspection will be continued, and, if the fruit fly is discovered, the State authorities will immediately institute eradication measures.

Apicultural Notes

While in Washington recently, A. W. B. Kjosness, general manager, and O. Lende, counsel, of the Mountain States Honey Producers' Association, conferred with the members of the Bee Culture staff and other Government officials in the Department of Agriculture.

Dr. R. L. Parker appeared on the program of the Beekeepers' Short Course at Missouri University, July 22, 1930 and judged the Bee and Honey Exhibit at the Missouri State Fair at Sedalia, Mo., and the Bee and Honey Exhibit at the Nebraska State Fair.

Harry H. Laidlaw, Jr., has been appointed Minor Scientific Helper, Bureau of Entomology, and assigned to duties at the Southern States Bee Culture Field Laboratory, Baton Rouge, La., and William C. Northrup has been appointed Assistant Scientific Aid, for service at the Intermountain Bee Culture Field Laboratory, Laramie, Wyo.

Dr. W. E. Dunham, of the Ohio State University, Columbus, who has been employed temporarily as Field Assistant, working on the problem pertaining to the use of honeybees in the pollination of red clover, stopped at the Bee Culture Laboratory at Washington on September 24 to discuss various phases of his summer's work.

J. E. Eckert, Associate Apiculturist, Bureau of Entomology, of the Intermountain Bee Culture Field Laboratory, Laramie, Wyo., spent several days at the Bee Culture Laboratory, conferring with various members of the staff in regard to his work on the flight range of the honeybee, and consulting the literature in the beekeeping library.

The vice-president of the Apis Club, an international organization of apiculturists, Jean Chaneaux, of Les Arsures (Jura), France, visited the Bee Culture laboratory September 18 and 19. Mr. Chaneauz stopped at Somerset at the conclusion of a ten months' visit to beekeepers of the United States. In this time he visited practically every important beekeeping State, and had personal interviews with many of the commercial beekeepers of the country.

Notes on Medical Entomology

F. C. Bishopp, Bureau of Entomology, returned to Washington September 17, after an extended trip through various western States to gather data concerning insects affecting cattle, and ticks and mosquitoes affecting man.

Dr. W. B. Johnson, Director of the Medical and Sanitary Service of Lagos, Nigeria, visited the Washington office September 25, to confer on problems in medical and veterinary entomology in the United States.

W. G. Bruce, Bureau of Entomology, of the field laboratory at Fargo, N. Dak., has been transferred to Dallas, Tex., for the fall and winter. He reached Dallas September 18, and will continue work on cattle grubs in Texas.

Errata

Page 98. In explanation of Plate 4.
In first line for 1, write 3.
In second line for 2, write 1.
In fourth line for 3, write 2.

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